UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
501 West Ocean Boulevard, Suite 4200
Long Beach, California 90802-4213

In Response Refer To:
151422SWR2005SA00681:JSS

APR 04 2006

James N. Seiber
Director
United States Department of Agriculture
Pacific West Area, Western Regional Research Center
Agricultural Research Service
800 Buchanan Street
Albany, California 94710-1105

Dear Director Seiber:

This letter transmits NOAA's National Marine Fisheries Service's (NMFS) biological and conference opinion (Enclosure 1) based on our review of the proposed Water Hyacinth Control Program (WHCP) in the Sacramento-San Joaquin Delta (Delta) in the state of California, and its effects on Federally listed endangered Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), threatened Central Valley spring-run Chinook salmon (*O. tshawytscha*), threatened Central Valley steelhead (*O. mykiss*), proposed threatened southern distinct population segment (DPS) of North American green sturgeon (*Acipenser medirostris*), and designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon and Central Valley steelhead in accordance with section 7 of the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 et seq.). Your September 9, 2005, request for formal consultation was received on September 14, 2005. A response was sent on October 19, 2005, indicating that NMFS would require additional information from the U.S. Department of Agriculture-Agricultural Research Services (USDA-ARS) in order to initiate the consultation process. A complete biological assessment was received from the USDA-ARS via the California Department of Boating and Waterways (DBW) that fulfilled the request for additional information on November 14, 2005.

This biological and conference opinion (Enclosure 1) is based on information provided from the annual reports for the WHCP from 2003, 2004, 2005, the September 9, 2005 request letter, the November 14, 2005 biological assessment, and the September 28, and November 4, 2005 meetings between staff from NMFS, the USDA-ARS, and DBW for the proposed WHCP project. A complete administrative record of this consultation is on file at the Sacramento, California, field office of NOAA Fisheries.

Based on the best available scientific and commercial information, the biological and conference opinion concludes that the WHCP, as proposed by the USDA-ARS and DBW, is not likely to jeopardize the continued existence of the listed or proposed species or adversely modify designated critical habitat. NMFS also has included an incidental take statement with reasonable and prudent measures and non-discretionary terms and conditions that are necessary and appropriate to avoid, minimize, or monitor incidental take associated with the project. The conference opinion concerning the proposed listing of green sturgeon does not take the place of consultation under section 7(a) 2 of the ESA. The conference opinion may be adopted as a biological opinion when the proposed listing for the southern DPS of North American green sturgeon becomes final if no significant new information is developed, and no significant changes to the project are made that would alter the contents of this opinion.

This letter also transmits NMFS' Essential Fish Habitat (EFH) conservation recommendations for Pacific salmon (*O. tshawytscha*), starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) as required by the Magnuson-Stevens Fishery Conservation and Management Act (MSA) as amended (16 U.S.C. 1801 *et seq.*; Enclosure 2). The document concludes that the WHCP will adversely affect the EFH of Pacific salmon, starry flounder, and English sole in the action area and adopts certain terms and conditions of the incidental take statement and the ESA conservation recommendations of the biological and conference opinion as the EFH conservation recommendations.

The USDA-ARS has a statutory requirement under section 305(b)(4)(B) of the MSA to submit a detailed response in writing to NMFS within 30 days of receipt of these conservation Recommendations that includes a description of the measures proposed for avoiding, mitigating, or offsetting the impact of the activity on EFH (50 CFR 600.920 (j)). If unable to complete a final response within 30 days, the Corps should provide an interim written response within 30 days before submitting its final response.

Please contact Mr. Jeffrey Stuart in our Sacramento Area Office at (916) 930-3607 or via e-mail at J.Stuart@noaa.gov if you have any questions regarding this response or require additional information.

Sincerely,

Russell M Strach

for Rodney R. McInnis
Regional Administrator

Enclosures (2)

cc:

NOAA Fisheries-PRD, Long Beach, CA
Stephen A. Meyer, ASAC, NOAA Fisheries, Sacramento, CA
USDA-ARS, Lars Anderson, Weed Science Program, UC-Davis - One Shields Avenue, Davis, CA 95616

DBW, Marcia Carlock, 2000 Evergreen Street, Suite 100, Sacramento, CA 95815

U.S. Fish and Wildlife Service, Ryan Olah, 2800 Cottage Way, Suite W-2605, Sacramento, CA 95825

James Starr, California Department of Fish and Game, 4001 North Wilson Way, Stockton, CA 94205

California Regional Water Quality Control Board, Emily Alejandro, 3443 Routier Road, Suite A, Sacramento, CA 95827

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BIOLOGICAL AND CONFERENCE OPINION

ACTION AGENCY: U.S. Department of Agriculture-Agricultural Research Service

ACTIVITY: Water Hyacinth Control Program

CONSULTATION CONDUCTED BY: Southwest Region, National Marine Fisheries Service

FILE NUMBER: 151422SWR2005SA00681:JSS

I. CONSULTATION HISTORY

Previous consultations by NOAA's National Marine Fisheries Service (NMFS) addressing the effects of the Water Hyacinth Control Program (WHCP) on listed salmonids resulted in the issuance of biological opinions on June 8, 2001; June 11, 2002; and August 11, 2003. These biological opinions respectively concluded that the WHCP was not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley steelhead (*O. mykiss*), or adversely modify designated critical habitat for the 2001, 2002, and 2003 through 2005 application seasons.

On September 14, 2005, NMFS received the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) request for initiation of formal section 7 consultation under the Endangered Species Act (ESA) for the WHCP covering application seasons 2006 through 2010.

On September 28, 2005, a meeting was held at NMFS' Sacramento offices between staff from the USDA-ARS, the California Department of Boating and Waterways (DBW) and NMFS to discuss the WHCP consultation and the necessary information to be included in the project's biological assessment (BA).

On October 19, 2005, NMFS formally responded to the USDA-ARS' request for formal section 7 consultation regarding the WHCP with a letter indicating that the information provided in the initiation package was incomplete and that further detailed information was necessary to continue the consultation. The information requested by NMFS had been discussed in the September 28, 2005 meeting between agency staff.

On November 4, 2005, a second meeting was held at NMFS' Sacramento offices between staff from the aforementioned agencies to discuss the progress of the BA.

On November 14, 2005, a copy of the final BA for the WHCP was delivered to the offices of NMFS in Sacramento by staff from the DBW and formal consultation was initiated for the project.

II. DESCRIPTION OF THE PROPOSED PROJECT

The DBW, through their Federal sponsor, the USDA-ARS, is proposing a continuation of their ongoing WHCP in the affected waters of the Central Valley of California for the next five years (2006-2010). The WHCP is an ongoing program that is designed to control the growth and spread of the invasive, non-native aquatic plant *Eichhornia crassipes* (water hyacinth) in the Sacramento – San Joaquin Delta (Delta), several tributaries that flow into the delta (*i.e.* Morrison Creek, and the Merced, Mokelumne, Tuolumne, and San Joaquin Rivers) as well as several sloughs that feed into the Delta. Tables and figures mentioned in text will be given in appendix A and B, respectively, at the end of the document. Please see Appendix B, Figure 1 for a map of the project action area.

A. Project objectives

The primary purpose of the WHCP is to prevent the growth and spread of water hyacinth in the affected areas of the Delta and its adjoining waters (DBW 2005b). The DBW has been charged with preventing degradation of the beneficial uses of the Delta waters by the infestation of the water hyacinth and thus seeks to minimize the negative impacts of the water hyacinth on navigation, recreation, and agricultural activities (diversions) in the affected waterways of the Delta. DBW will clear and maintain adequate navigation channels for Delta boaters and clear infested waters surrounding marinas, boat launching ramps, agricultural diversions, and domestic water pumping intakes. In addition to these stated primary objectives, DBW seeks to improve the Delta's aquatic habitat by removing the non-native water hyacinth and creating opportunities for native plants to recolonize the infested areas. The DBW has identified a total of ten specific objectives to be achieved by the WHCP and their associated performance measures that will be used to evaluate the success of the WHCP (Table 1).

Table 1: WHCP Objectives and Performance Measures (from DBW 2005)

Objectives	
1.	Limit future growth and spread of water hyacinth in the Delta.
2.	Improve boat and vessel navigation in the Delta.
3.	Utilize the most efficacious methods available with the least environmental impacts.
4.	Prioritize sites so that the WHCP activities are focused on sites with a high degree of infestation, as well as navigational, agricultural, or recreational significance.
5.	Employ a combination of control methods to allow maximum flexibility.
6.	Improve the WHCP as more information becomes available on control methods used in the Delta.
7.	Monitor results of the WHCP to fully understand impacts of the WHCP on the environment of the Delta.
8.	Improve shallow water habitats for native species by controlling water hyacinth.
9.	Decrease WHCP control efforts, when and if sufficient efficacy of water hyacinth control is realized.
10.	Minimize use of methods that could cause adverse environmental impacts.

Performance Measures
• Reduce total acres of water surface infested with water hyacinth
• Reduce water hyacinth biomass at high priority navigation sites currently infested with water hyacinth
• Reduce water hyacinth biomass at nursery sites.
• Prevent infestation of new sites.
• Produce fewer incidents of boat navigation, agricultural, and recreation problems related to water hyacinth.
• Prepare reports for regulatory agencies
• Increase the total efficacy level of the WHCP, and each control method over time.
• Increase the number of shallow-water sites suitable for native species.
• Limit the number and significance of environmental impacts resulting from the WHCP.
• Limit the number of acres treated with methods that have the potential for adverse environmental impacts.
• Reduce the quantity of herbicides applied to the Delta over time.

B. Project Activities

The WHCP is a program intended to control water hyacinth, an invasive, non-native aquatic weed in the Delta. The Federal nexus for this activity is the USDA-ARS, which has the responsibility to conduct research and provide technical input into the control of nuisance weeds and agricultural pests. The DBW is the state lead for this project, with whom the USDA-ARS has contracted with to conduct the application of the program.

1. Chemical Control

Currently, the primary WHCP treatment methods utilize chemical herbicides in conjunction with adjuvents. The chemical compounds available to the DBW for application to infested waters during the 2006-2010 treatment seasons include:

a. *Herbicides*

1. Reward® (active ingredient: diquat dibromide, Environmental Protection Agency (EPA) Registration Number 10182-404)

2. Weedar 64® (active ingredient: 2,4-Dichlorophenoxyacetic acid (2,4-D), dimethylamine salt). EPA Registration Number 71368-264.

3. Rodeo® and Aquamaster (active ingredient glyphosate). EPA Registration Number 524-00343.

b. *Adjuvants*

1. R-11® Spreader-Activator (active ingredients: alkyl aryl polyethoxylates, compounded silicone, and linear alcohol). California State Registration 2935-50142-AA.

2. Agri-Dex® (active ingredients: paraffin base petroleum oil and polyoxyethylate polyol fatty acid esters). California State Registration 5905-50017-AA.

Of the three aquatic herbicides selected for use in the program, only two have been used regularly, 2,4-D and glyphosate. These will remain the two preferred herbicides for use during the 2006 to 2010 application seasons. The compound 2,4-D accounted for between 75 percent and 90 percent of the herbicides applied in the past three treatment seasons for the WHCP and glyphosate has accounted for the remainder. DBW has not determined whether the herbicide diquat dibromide will be used during the next five application seasons.

In addition to the herbicides, two different adjuvants have been used in the application program during the period from 2003 to 2005. They are: (1) R-11®, a combined spreading-activating compound for increasing the efficiency of action for agricultural chemicals where quick wetting and uniform coverage are required and (2) Agri-Dex®, a nonionic compound that improves pesticide application by modifying the wetting and deposition characteristics of the application solution.

Agri-Dex® will be the primary adjuvant used in the WHCP. R-11 has been deemed unsuitable for the majority of applications in the waters of the Delta. R-11 can, however, be used in portions of the Stone/Beach Lakes complex where contact with listed fish species is unlikely to occur.

Please see Table 2 (Appendix A) for an accounting of chemical usage and acreage treated for the 2003 through 2005 application seasons (DBW 2004, 2005a, 2006).

2. Biological Control

The USDA-ARS and DBW are conferring with the California Department of Food and Agriculture (DFA) to develop and implement biological control methods for the WHCP. The DBW has contracted with the DFA to search for populations of weevils belonging to the genus *Neochetina* within the Delta. These weevils are a naturally occurring consumer of the water hyacinth, endemic to the plant's native South American habitat. This genus of weevils was previously released into the Delta several decades ago, but had not established a large enough population to achieve control of the water hyacinth infestation. Remnant populations of these earlier releases still remain in the Delta, but are scattered and small in size. If populations of these weevils are found, DFA will determine if they are infected with a microsporidian disease that could interfere with biological control efforts. DBW intends to utilize these weevils to colonize water hyacinth nurseries and establish self-sustaining populations of the insect as an ongoing control of water hyacinth infestation in these locales. Pending the results of the DFA investigations, DBW intends to submit a final biological control study proposal to NMFS to be included as an amendment to this or future biological opinions, which will fulfill earlier requirements to establish an integrated pest management program for water hyacinth in the Delta as described in the project's biological assessment (DBW 2005b). Therefore, biological control operations will not be addressed further in this biological opinion.

3. Mechanical and Physical Removal

The DBW has received concurrence under a separate consultation (SWR-03-SA-8373:JSS) to implement a manual and mechanical removal of water hyacinth infestations from Delta waterways during the non-spraying season. This period is typically from the end of the herbicide spraying season in mid October (October 15) to the beginning of the permitted herbicide spray application season in spring (date varies depending on location). Personnel from the DBW will manually remove small infestations of water hyacinth with rakes in critical areas and deposit the vegetation on adjacent levee banks where the plants will desiccate naturally and perish. Mechanical removal will require DBW personnel to use motorized water-craft to "herd" mats of water hyacinth out into the main channels of the Delta where they will be carried by currents out of the Delta system and eventually perish in the higher salinity of Suisun Bay. Mechanical and physical removal operations will not be further addressed in this biological opinion.

4. Daily Protocol

The proposed WHCP treatment season would extend from approximately April 1 through October 15. Five crews, each consisting of a Specialist and a Technician, would carry out the spraying of herbicides in an assigned region of the Delta. Spraying would be conducted five days a week, with each team spraying about 25 acres per day in total, at one to three sites in a given day. The maximum area that could be treated in a day could range as high as 50 acres a day in the summer, when crews work overtime and weather and tidal conditions are conducive to treatment. A Field Supervisor would manage daily operations from the DBW Field Office in Stockton, California, and would be responsible for determining daily spraying needs and assign teams to sites based on local conditions, available personnel, and equipment resources. The Field Supervisor will also assure that the Notice of Intent (NOI) requirements are met by reporting the locations of the treatment sites to the respective county Agricultural Commissioner no later than the Friday prior to the week of treatment. Each boat crew will document herbicide applications on a daily basis, make sure that application rates are compliant with label instructions for each respective chemical product, are applied at designated treatment sites only, are performed in a manner consistent with the WHCP protocols and use permits, and overseen by the Project Supervisor. The application of herbicides will be conducted with hand held sprayers operated from 19 to 21-foot aluminum air or outboard boats. The boats are equipped for direct metering of herbicides, adjuvants and water into the pump system of the spraying unit. The herbicide/adjuvant mixture will be sprayed directly onto the floating mats of water hyacinth. Waste products, including both active and inert components of the herbicidal mixtures, degraded components of the herbicidal mixtures, and dead and decaying vegetable matter, would be left to sink to the bottom or be carried downstream by the river and tidal currents. Operating protocols will prohibit treatments when wind conditions exceed a maximum threshold (10 mph) or when water flow or wave action is excessive.

The DBW will follow the California Department of Pesticide Regulation procedures for pesticide application. Restricted Use Permits from the relevant county agriculture commissioners will be obtained prior to the initiation of the spraying program. Monitoring protocols for water quality and pesticide concentrations in treated water bodies will be strictly adhered to in compliance with the water quality monitoring protocols approved by the Central Valley Regional Water Quality Board (Regional Board) per the criteria set forth in the General Permit.

C. Proposed Conservation Measures

The DBW was initially covered under the Individual Permit issued by the Regional Board on March 7, 2001 for the application of herbicides in conjunction with the WHCP. This order expires March 7, 2006. On April 12, 2002, the USDA-ARS and DBW applied for a General Permit under the "emergency basis" resulting from the <u>Headwaters, Inc. v. Talent Irrigation District</u> (Talent Decision) issued in 2001 by the Ninth Circuit Court of Appeals. As a requirement of the General Permit, the DBW would follow monitoring protocol terms imposed by the Regional Board. The general goals of the monitoring plan are to:

1. Document compliance with the requirements of the General Permit

2. Support the development, implementation, and effectiveness of the implementation of Best Management Procedures (BMPs)

3. Demonstrate the full recovery of water quality and protection of beneficial uses of the receiving waters following completion of resource or pest management projects

4. Identify and characterize aquatic pesticide application projects conducted by the DBW

5. Assure that the Monitoring Plan provides for monitoring of projects that are representative of all pesticides and application methods used by the DBW.

The General Permit does not specify numeric limits for water quality criteria, but rather gives narrative guidelines for dischargers to follow. The General Permit allows for temporary excursions above the numeric criteria listed in the California Toxics Rule (CTR) and EPA water quality criteria, as long as full restoration of water quality and beneficial uses of the receiving waters are returned to pre-treatment levels following completion of the action. However, DBW anticipates following both the EPA aquatic species toxicity limits and drinking water standards that follow:

- Diquat--the maximum-labeled rate for water column concentration is 370 parts per billion (ppb). The EPA drinking water concentration standard (Maximum Contaminant Level, or MCL) is 20 ppb. EPA lists the protective criteria for freshwater life as 0.5 ppb. The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

- Glyphosate--application rates will be limited to ensure a MCL that does not exceed 700 ppb in water bodies designated as municipal and domestic water supplies. The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

- 2,4-D--the application rate will be limited to ensure a MCL that does not exceed 70 ppb in water bodies designated as municipal or domestic water supplies. Regional Board has further restricted the level of permissible 2,4-D concentrations in receiving waters to 20 ppb in the individual National Pollution Discharge Elimination System (NPDES) permit (Section A-14, Receiving Water Limitations). The DBW anticipates treating within the labeled rates the day of treatment and returning to EPA criteria within 24 hours after treatment.

In order to fulfill the requirements of the General Permit, the DBW has implemented pre-treatment and post-treatment monitoring for biological, chemical, and physical indicators associated with each form of WHCP treatment. These elements are required according to the terms of the monitoring plan associated with the General Permit (Attachment B of the General Permit). The objectives of the program's monitoring are to: (1) determine if environmental conditions are conducive to chemical or mechanical treatment; (2) collect data for environmental baseline conditions, for assessment of environmental impacts and treatment efficacy, and (3) determine if treatment protocols need to be modified to reduce environmental impacts.

Pre-treatment monitoring involves taking measurements of physical and chemical parameters, including water temperature, water flow rate, turbidity, dissolved oxygen (DO), pH, and concentrations of aquatic herbicides prior to treatment. Post-treatment monitoring consists of taking measurements of DO, pH, and aquatic herbicides concentrations. Water hyacinth biomass and coverage are quantified before and after treatment to determine overall efficacy of the WHCP and possible modifications to the treatment protocol. Specific mitigation measures for the water hyacinth control program are proposed by the DBW to avoid or minimize potential impacts where available. Consultation with various state and federal agencies regarding impacts and mitigation measures for future revisions or additions to the mitigation measures will be on going.

1. <u>Environmental Monitoring</u>

The monitoring program includes a daily log with site specifics (*e.g.* location, wind, chemicals used, location of listed species/species habitat), DO levels, pH, and pre-treatment and post-treatment levels of chemical residues. Three times each year, replicated (n=2) monitoring of pre-treatment and post-treatment chemical residue concentrations will be conducted in each of the water type categories (tidal, slow-moving, fast-flowing, dead-end slough). Each type of herbicide applied will have a complete set of residue determinations performed.

2. <u>Pre-Treatment</u>

One hour prior to treatment, readings of the ambient DO, temperature, and turbidity will be taken in the treatment area at the midpoint of the water column or at a depth of 5 feet, whichever is closer to the surface. An ambient chemical residue sample will also be taken in the treatment area at the midpoint of the water column or at a depth of 5 feet, whichever is closer to the surface, and within 3 feet of the water hyacinth mat, if possible, at the same location.

3. Post-Treatment

Upon completion of the chemical application, DBW will take ambient DO, temperature and turbidity readings at the mid-point of the water column or at a depth of 5 feet; whichever is closer to the surface, at the following three locations:

1. 100 feet up current of the treatment area.
2. Within the treatment area at the same location as the pre-treatment sample; and
3. 25 feet down-current of the treatment area

These DO, temperature and turbidity readings will continue until dead plants are no longer observable and the DO readings within and 25 feet down-current of the treatment area are within 0.5 mg/L of the readings 100 feet up-current of the treatment area.

Chemical residue and toxicity samples:

- Direction of water flow will be determined prior to the initiation of spraying. After the initial water sample has been taken, the spray crew will flag the starting point and spray in a down-current direction, traveling with the current.

- When the spray crew has passed the initial sampling location, the monitoring crew will take the first post-treatment sample 100 feet upstream of the flagged starting point.

- The monitoring crew will then take the second sample at the initial sample location for chemical residue and toxicity studies. The monitoring crew will contact the spraying crew to stop at this point, and the spraying crew will flag the end point of the application area.

- The monitoring crew will sample water 25 feet down-current from the flagged stopping point.

The time, latitude, and longitude of the sampling location for each set of samples will be recorded for later incorporation into a GIS database.

The DBW has Memoranda of Understanding (MOUs) with regional water agencies outlining application restrictions. Prior to any future work within close proximity of drinking water intakes, the DBW will develop a protocol for sampling post-treatment chemical residue around the intakes. Currently, label recommendations for Reward® concentration cannot exceed 20 ppb in drinking water.

Other monitoring protocols being carried out by DBW and relevant to listed salmonid species includes field observations for any dead fish and native vegetation; visual assessment of water quality and photo documentation of native vegetation present at treatment sites before and after chemical control applications.

The WHCP technical crew is trained in fish species identification and recognition of fish habitat in the Delta and associated waterways by the DBW environmental scientist assigned to the program.

4. WHCP Adaptive Management

The DBW proposes to employ an adaptive management strategy for conducting the WHCP. This strategy will allow the DBW to re-evaluate its project protocol as new data and information becomes available that enhances the efficiency of the program or minimizes its environmental impact. The proposed adaptive management strategies include:

- Evaluating the need for control measures on a site by site basis;
- Selecting appropriate indicators for pre-treatment environmental monitoring;
- Monitoring indicators following treatment and evaluating data to determine program efficacy and environmental impacts;
- Support ongoing research to explore the impacts of the WHCP and alternative control methodologies;
- Report findings from monitoring evaluations and research to regulatory agencies and stakeholders;
- Adjust program actions, as necessary, in response to recommendations and evaluations by regulatory agencies and stakeholders.

5. Temporal and Spatial Restrictions to Herbicide Applications

The application of herbicides in the waters of the action area has been modified by DBW, in response to on-going consultations with NMFS, to minimize or avoid potential adverse effects upon listed salmonids and North American green sturgeon. DBW has indicated that the following temporal and spatial limitations and restrictions will be incorporated into their application protocols for the WHCP and become part of the project description:

1. The following sites may be treated from April 1 to November 30 under the following specified conditions:

    a. The San Joaquin River upstream of the confluence with the Merced River (Hills Ferry) and associated sloughs and canals in Merced and Fresno counties south of the confluence of the Merced and San Joaquin Rivers;

   b. The Stone/Beach Lakes complex in Sacramento County (except for site 220, which will only be treated April 1 through October 15).

2. The following sites may be treated April 1 through October 15 of each application season. Treated sections will start at the inner margin of the infested water body and move progressively outwards towards the main channel as practicable:

   a. Sloughs on the east side of the Delta which have minimal current and unsuitable salmonid habitat:
      i. Fourteen Mile Slough east of Shima Tract
      ii. Pixley Slough
      iii. Rio Blanco Tract
      iv. White and Disappointment Sloughs, east of Honker Cut
      v. Sycamore Slough
      vi. Hog Slough
      vii. Beaver Slough
      viii. Lost Slough
      ix. Snodgrass Slough above the Delta Cross Channel

3. Areas available to herbicide treatment from April 15 through October 15 are portions of the south Delta that are within the region bounded by the placement of the four south Delta temporary barriers. Herbicide applications may commence once the barriers are in place and the Head of Old River Barrier is closed. These waterways include portions of Old River, Middle River, Paradise Cut, Salmon Cut, Tom Paine Slough, Sugar Slough, Grant Line, Fabian and Bell Canals. Additionally, off channel sites along the Merced River that have no hydrological connectivity to the mainstem Merced River may also be treated as early as April 15.

4. Treatment may occur as early as May 15 (but continue no later than October 15) in the Merced River, Tuolumne River and the mainstem San Joaquin River upstream of the confluence with the Stanislaus River to the confluence with the Merced River depending on water temperatures, with the stipulation that water temperatures must be 21 ^{o}C (69.8 ^{o}F) or greater for one week prior to the application of herbicides in each prospective area.

5. The remainder of the project area may be treated after June 1, or when Interagency Ecological Program (IEP) data indicates that the pulse of migrating salmon have moved through the Delta. If IEP data shows that fish are still present in these reaches, spraying activities may be suspended upon the discretion of NMFS personnel.

6. Between July 1 and October 15, there are no restrictions for areas to be sprayed within the project area.

D. Action Area

The WHCP includes portions of nine counties that encompass much of the Sacramento-San Joaquin Delta and its upland tributaries. The nine counties are: Contra Costa, Fresno, Madera, Merced, Sacramento, San Joaquin, Stanislaus, and Yolo. Merced and Fresno counties will be treated by the agricultural commissions of those counties under the direction of the DBW. The DBW will conduct the program in the other seven counties. The general boundaries for the treatment area in the Delta and its tributaries are as follows:

- West up to and including Sherman Island, at the confluence of the Sacramento and San Joaquin Rivers;

- West up to the Sacramento Northern Railroad to include water bodies north of the southern confluence of the Sacramento River and the Sacramento River Deep Water Ship Channel (SDWSC);

- North to the northern confluence of the Sacramento River and the SDWSC, plus waters of Lake Natoma;

- South along the San Joaquin River and Kings River to Mendota, just west of Fresno;

- East along the San Joaquin River to Friant Dam on Millerton Lake;

- East along the Tuolumne River to La Grange Reservoir; below Don Pedro Reservoir; and

- East along the Merced River to Merced Falls, below Lake McClure.

Within the project area are 367 possible treatment sites which average between one and two miles in length (see Table 3, Appendix A). These sites include those that were listed in the 2002 WHCP, sites that were omitted from the action area in 2002, and additional sites that have been added to the WHCP since 2003. Each year, sites will be prioritized after DBW crews complete a spring survey. High priority sites will generally have the greatest impacts to navigation, create extensive obstructions to pumping facilities, or have high levels of infestation.

III. STATUS OF THE SPECIES AND CRITICAL HABITAT

The following Federally listed and proposed species (Evolutionarily Significant Units [ESUs] or Distinct Population Segments [DPSs]) and designated critical habitat occur in the action area and may be affected by the proposed project:

Sacramento River winter-run Chinook salmon ESU
endangered (June 28, 2005, 70 FR 37160)

Sacramento River winter-run Chinook salmon critical habitat
(June 16, 1993, 58 FR 33212)

Central Valley spring-run Chinook salmon ESU
threatened (June 28, 2005, 70 FR 37160)

Central Valley spring-run Chinook salmon critical habitat
(September 2, 2005, 70 FR 52488)

Central Valley steelhead DPS
Threatened (January 5, 2006 71 FR 834)

Central Valley steelhead designated critical habitat
(September 2, 2005, 70 FR 52488)

Southern DPS of North American green sturgeon (*Acipenser medirostris*)
proposed threatened (April 6, 2005, 70 FR 17386)

The designated critical habitat of Sacramento River winter-run Chinook salmon occurs along the main channel of the Sacramento River downstream to Chipps Island and includes Sutter, Steamboat, and Cache Sloughs as well as the lower segments of the San Joaquin River adjacent to Kimball, Browns and Winter Islands near RM 4 of the San Joaquin River. Critical habitat is inclusive of the aquatic habitat below the ordinary high water mark surrounding these islands and along the river and slough channels. Designated critical habitat for Central Valley steelhead occurs throughout the waters of the Delta and within the eastside tributaries below the first impassable barrier (Calaveras, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers). Critical habitat extends up the lower section of the San Joaquin River to Hills Ferry, located at the confluence of the Merced River. Critical habitat lies below the ordinary high water mark in these waters. Designated critical habitat for Central Valley spring-run Chinook salmon borders the northern edge of the San Joaquin River from the confluence of the Mokelumne River west to the boundaries of the Suisun Bay and Sacramento Delta hydrologic sub units at approximately RM 4 of the San Joaquin River. This would include the waters of Three Mile Slough and New York Slough. Critical habitat for spring-run Chinook salmon in the action area includes the Sacramento River from Sherman Island upriver to the City of Sacramento, and would include the waters of Steamboat, Sutter, Miner, and Elk Sloughs. Individuals of both Chinook salmon ESUs can occupy waters within the action area during their migratory or rearing phases.

A. Species and Critical Habitat Listing Status

NMFS has recently completed an updated status review of 16 salmon ESUs, including Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon, and concluded the species' status should remain as previously listed (70 FR 37160). On January 5, 2006, NMFS published a final listing determination for ten steelhead DPSs, including Central Valley steelhead and concludes that Central Valley steelhead will remain listed as threatened (71 FR 834).

Sacramento River winter-run Chinook salmon were originally listed as threatened in August 1989, under emergency provisions of the ESA, and formally listed as threatened in November 1990 (55 FR 46515). The ESU consists of only one population that is confined to the upper

Sacramento River in California's Central Valley. The Livingston Stone National Fish Hatchery population has been included in the listed Sacramento River winter-run Chinook salmon population as of June 28, 2005 (70 FR 37160). NMFS designated critical habitat for winter-run Chinook salmon on June 16, 1993 (58 FR 33212). The ESU was reclassified as endangered on January 4, 1994 (59 FR 440), due to increased variability of run sizes, expected weak returns as a result of two small year classes in 1991 and 1993, and a 99 percent decline between 1966 and 1991. Critical habitat was delineated as the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta, including Kimball Island, Winter Island, and Brown's Island; all waters from Chipps Island westward to the Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and the Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay north of the San Francisco-Oakland Bay Bridge. The critical habitat designation identifies those physical and biological features of the habitat that are essential to the conservation of the species and that may require special management consideration and protection. Within the Sacramento River this includes the river water, river bottom (including those areas and associated gravel used by winter-run Chinook salmon as spawning substrate), and adjacent riparian zone used by fry and juveniles for rearing. In the areas west of Chipps Island, including San Francisco Bay to the Golden Gate Bridge, this designation includes the estuarine water column, essential foraging habitat, and food resources utilized by winter-run Chinook salmon as part of their juvenile outmigration or adult spawning migrations.

Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999 (50 FR 50394). This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. The Feather River Hatchery (FRH) spring-run Chinook salmon population has been included as part of the Central Valley spring-run Chinook salmon ESU as of June 28, 2005 (70 FR 37160). Critical habitat was designated for spring-run Chinook salmon in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the Feather and Yuba Rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear Creeks, and the Sacramento River and Delta.

Central Valley steelhead were listed as threatened under the ESA on March 19, 1998 (63 FR 13347). This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. The Coleman National Fish Hatchery and FRH steelhead populations have been included in the listed population of steelhead as of January 5, 2006 (71 FR 834). These populations were previously included in the DPS but were not deemed essential for conservation and thus not part of the listed steelhead population. Critical habitat was designated for steelhead in the Central Valley on September 2, 2005 (70 FR 52488). Critical habitat includes the stream channels to the ordinary high water line within designated stream reaches such as those of the American, Feather, and Yuba Rivers, and Deer, Mill, Battle, Antelope, and Clear Creeks in the Sacramento River basin; the Calaveras, Mokelumne, Stanislaus, and Tuolumne Rivers in the San Joaquin River basin; and, the Sacramento and San Joaquin Rivers and Delta.

The southern DPS of North American green sturgeon was proposed for listing as threatened on April 6, 2005 (70 FR 17386). The southern DPS presently contains only a single spawning population in the Sacramento River; individuals may occur in the action area. No critical habitat has been designated or proposed for the southern DPS of North American green sturgeon.

B. Species Life History, Population Dynamics, and Likelihood of Survival and Recovery

1. Chinook Salmon

a. *General Life History*

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a year or more following emergence, whereas "ocean-type" Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in fall, and the juveniles typically spend a year or more in freshwater before emigrating. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream- and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over-summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime, and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the mainstem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require streamflows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate streamflows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38 ºF to 56 ºF (Bell 1991, California Department of Fish and Game (CDFG) 1998). Adult winter-run Chinook salmon enter San Francisco Bay from November through June (Hallock and Fisher 1985) and migrate past Red Bluff Diversion Dam (RBDD) from mid-December through early August (NMFS 1997). The majority of the run passes RBDD from January through May, with the peak passage occurring in mid-March (Hallock and Fisher 1985). The timing of migration may vary somewhat due to changes in river flows, dam operations, and water year type. Adult spring-run Chinook salmon enter the Delta from the Pacific Ocean beginning in January and enter natal streams from March to July (Myers *et al.*

1998). In Mill Creek, Van Woert (1964) noted that of 18,290 spring-run Chinook salmon observed from 1953 to 1963, 93.5 percent were counted between April 1 and July 14, and 89.3 percent were counted between April 29 and June 30. Typically, spring-run Chinook salmon utilize mid- to high elevation streams that provide appropriate temperatures and sufficient flow, cover, and pool depth to allow over-summering while conserving energy and allowing their gonadal tissue to mature.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for redd construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (U.S. Fish and Wildlife Service (FWS) 1995). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. Bell (1991) identifies the preferred water temperature for adult spring-run Chinook salmon migration as 38 ^{o}F to 56 ^{o}F. Boles (1988) recommends water temperatures below 65 ^{o}F for adult Chinook salmon migration, and Lindley *et al.* (2004) report that adult migration is blocked when temperatures reach 70 ^{o}F, and that fish can become stressed as temperatures approach 70 ^{o}F. The Bureau of Reclamation (Reclamation) reports that spring-run Chinook salmon holding in upper watershed locations prefer water temperatures below 60 ^{o}F; although, salmon can tolerate temperatures up to 65 ^{o}F before they experience an increased susceptibility to disease. The upper preferred water temperature for spawning Chinook salmon is 55 ^{o}F to 57 ^{o}F (Chambers 1956, Bjornn and Reiser 1995). Winter-run Chinook salmon spawning occurs primarily from mid-April to mid-August, with the peak activity occurring in May and June in the Sacramento River reach between Keswick dam and RBDD (Vogel and Marine 1991). The majority of winter-run Chinook salmon spawners are 3-years old. Physical Habitat Simulation Model (PHABSIM) results (FWS 2003a) indicate winter-run Chinook salmon suitable spawning velocities in the upper Sacramento River are between 1.54 feet per second (ft/s) and 4.10 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter. Initial habitat suitability curves (HSCs) show spawning suitability rapidly decreases for water depths greater than 3.13 feet (FWS 2003a). Spring-run Chinook salmon spawning occurs between September and October depending on water temperatures. Between 56 and 87 percent of adult spring-run Chinook salmon that enter the Sacramento River basin to spawn are 3 years old (Calkins *et al.* 1940, Fisher 1994). PHABSIM results indicate spring-run Chinook salmon suitable spawning velocities in Butte Creek are between 0.8 ft/s and 3.22 ft/s, and suitable spawning substrates are between 1 and 5 inches in diameter (FWS 2004). The initial HSC showed suitability rapidly decreasing for depths greater than 1.0 feet, but this effect was most likely due to the low availability of deeper water in Butte Creek with suitable velocities and substrates rather than a selection by spring-run Chinook salmon of only shallow depths for spawning (FWS 2004).

The optimal water temperature for egg incubation is 44 ^{o}F to 54 ^{o}F (Rich 1997). Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The length of time required for eggs to develop and hatch is dependent on water temperature and is quite variable. Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61 ^{o}F and 37 ^{o}F, respectively, when the incubation temperature was held constant.

Winter-run Chinook salmon fry begin to emerge from the gravel in late June to early July and continue through October (Fisher 1994), with emergence generally occurring at night. Spring-run Chinook salmon fry emerge from the gravel from November to March and spend about 3 to 15 months in freshwater habitats prior to emigrating to the ocean (Kjelson *et al.* 1981). Post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris. They then begin feeding on small insects and crustaceans.

When juvenile Chinook salmon reach a length of 50 to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Stream flow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration. Emigration of juvenile winter-run Chinook salmon past RBDD may begin as early as mid-July, typically peaks in September, and can continue through March in dry years (Vogel and Marine 1991, NMFS 1997). From 1995 to 1999, all winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001). The emigration timing of Central Valley spring-run Chinook salmon is highly variable (CDFG 1998). Some fish may begin emigrating soon after emergence from the gravel, whereas others over-summer and emigrate as yearlings with the onset of intense fall storms (CDFG 1998). The emigration period for spring-run Chinook salmon extends from November to early May, with up to 69 percent of the young-of-the-year fish outmigrating through the lower Sacramento River and Delta during this period (CDFG 1998).

Fry and parr may rear within riverine or estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlane and Norton 2002). Shallow water habitats are more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54 ºF to 57 ºF (Brett 1952). In Suisun and San Pablo Bays water temperatures reach 54 ºF by February in a typical year. Other portions of the Delta (*i.e.*, South Delta and Central Delta) can reach 70 ºF by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

As Chinook salmon fry and fingerlings mature, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healy 1980, 1982; Levings *et al.* 1986). Juvenile winter-run Chinook salmon occur in the Delta from October through early May based on data collected from trawls, beach seines, and salvage records at the Central Valley Project (CVP) and State Water Project (SWP) pumping facilities (CDFG 1998). The peak of listed juvenile salmon arrivals in the Delta generally occurs from January to April, but may extend into June. Upon arrival in the Delta, winter-run Chinook salmon spend the first 2 months rearing in the more upstream, freshwater portions of the Delta (Kjelson *et al.* 1981, 1982). Data from the CVP and SWP salvage records indicate that most spring-run Chinook salmon smolts are present in the Delta from mid-March through mid-May depending on flow conditions (CDFG 2000).

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1986) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper 3 meters of the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Winter-run Chinook salmon fry remain in the estuary (Delta/Bay) until they reach a fork length of about 118 mm (*i.e.*, 5 to 10 months of age) and then begin emigrating to the ocean perhaps as early as November and continuing through May (Fisher 1994, Myers *et al.* 1998). Little is known about estuarine residence time of spring-run Chinook salmon. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry. Spring-run yearlings are larger in size than fall-run yearlings and are ready to smolt upon entering the Delta; therefore, they are believed to spend little time rearing in the Delta.

b. *Population Trend – Sacramento River Winter-run Chinook Salmon*

The distribution of winter-run Chinook salmon spawning and rearing historically was limited to the upper Sacramento River and its tributaries, where spring-fed streams allowed for spawning, egg incubation, and rearing in cold water (Slater 1963, Yoshiyama *et al.* 1998). The headwaters of the McCloud, Pit, and Little Sacramento Rivers, and Hat and Battle Creeks, historically provided clean, loose gravel; cold, well-oxygenated water; and, optimal stream flows in riffle habitats for spawning and incubation. These areas also provided the cold, productive waters necessary for egg and fry development and survival, and juvenile rearing over the summer. The construction of Shasta Dam in 1943 blocked access to all of these waters except Battle Creek, which has its own impediments to upstream migration (*i.e.*, the fish weir at the Coleman National Fish Hatchery and other small hydroelectric facilities situated upstream of the weir) (Moyle *et al.* 1989; NMFS 1997, 1998). Approximately, 299 miles of tributary spawning habitat in the upper Sacramento River is now inaccessible to winter-run Chinook salmon. Yoshiyama *et al.* (2001) estimated that in 1938, the Upper Sacramento had a "potential spawning capacity" of 14,303 redds. Most components of the winter-run Chinook salmon life history (*e.g.*, spawning, incubation, freshwater rearing) have been compromised by the habitat blockage in the upper Sacramento River.

Following the construction of Shasta Dam, the number of winter-run Chinook salmon initially declined but recovered during the 1960s. The initial recovery was followed by a steady decline from 1969 through the late 1980s following the construction of the RBDD. Since 1967, the estimated adult winter-run Chinook salmon population ranged from 117,808 in 1969, to 186 in 1994 (FWS 2001a, b; CDFG 2002b). The population declined from an average of 86,000 adults in 1967 to 1969 to only 1,900 in 1987 to 1989, and continued to remain low, with an average of 2,500 fish for the period from 1998 to 2000 (see Appendix B: Figure 2). Between the time Shasta Dam was built and the listing of winter-run Chinook salmon as endangered, major impacts to the population occurred from warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, acid mine drainage from Iron Mountain Mine, and entrainment at a large number of unscreened or poorly-screened water diversions (NMFS 1997, 1998).

Population estimates in 2001 (8,224), 2002 (7,441), 2003 (8,218), and 2004 (7,701) show a recent increase in the escapement of winter-run Chinook salmon. The 2003 run was the highest since the listing. Winter-run Chinook salmon abundance estimates and cohort replacement rates since 1986 are shown in Table 3. The population estimates from the RBDD counts have increased since 1986 (CDFG 2004a), there is an increasing trend in the 5-year moving average (491 from 1990-1994 to 5,451 from 1999-2003); and, the 5-year moving average of cohort replacement rates has increased and appears to have stabilized over the same period (Table 3).

Table 4. Winter-run Chinook salmon population estimates from RBDD counts, and corresponding cohort replacement rates for the years since 1986 (CDFG 2004a, Grand Tab CDFG February 2005).

Year	Population Estimate (RBDD)	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated Juvenile Production Estimate (JPE)[a]
1986	2,596	-	-	-	
1987	2,186	-	-	-	
1988	2,885	-	-	-	
1989	696	-	0.27	-	
1990	433	1,759	0.20	-	
1991	211	1,282	0.07	-	40,100
1992	1,240	1,092	1.78	-	273,100

1993	387	593	0.90	0.64	90,500
1994	186	491	0.88	0.77	74,500
1995	1,297	664	1.05	0.94	338,107
1996	1,337	889	3.45	1.61	165,069
1997	880	817	4.73	2.20	138,316
1998	3,002	1,340	2.31	2.48	454,792
1999	3,288	1,961	2.46	2.80	289,724
2000	1,352	1,972	1.54	2.90	370,221
2001	8,224	3,349	2.74	2.76	1,864,802
2002	7,441	4,661	2.26	2.22	2,136,747
2003	8,218	5,705	6.08	3.02	1,896,649
2004	7,701	6,587	0.94	2.71	881,719
2005	15,730	9,463	2.11	2.83	3,831,286
median	1,769	1,550	1.78	2.49	338,107

[a]JPE estimates were derived from NMFS calculations utilizing RBDD winter-run counts through 2001, and carcass counts thereafter for deriving adult escapement numbers.

c. *Status - Sacramento River Winter-run Chinook Salmon*

Numerous factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing, and migration habitats. The primary impacts include blockage of historical habitat by Shasta and Keswick Dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates, and entrainment in a large number of unscreened or poorly screened water diversions within the Central Valley. Secondary factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, and interactions with, and predation by, introduced non-native species (NMFS 1997, 1998).

Since the listing of winter-run Chinook salmon, several habitat problems that led to the decline of the species have been addressed and improved through restoration and conservation actions. The impetus for initiating restoration actions stems primarily from the following: (1) ESA section 7 consultation Reasonable and Prudent Alternatives (RPAs) on temperature, flow, and operations of the CVP and SWP; (2) Regional Board decisions requiring compliance with Sacramento River water temperatures objectives which resulted in the installation of the Shasta Temperature Control Device in 1998; (3) a 1992 amendment to the authority of the CVP through the Central Valley Project Improvement Act (CVPIA) to give fish and wildlife equal priority with other CVP objectives; (4) fiscal support of habitat improvement projects from the California Bay Delta Authority (CALFED) Bay-Delta Program (*e.g.*, installation of a fish screen on the Glenn-Colusa Irrigation District (GCID) diversion); (5) establishment of the CALFED Environmental Water Account (EWA); (6) EPA actions to control acid mine runoff from Iron Mountain Mine; and, (7) ocean harvest restrictions implemented in 1995.

The susceptibility of winter-run Chinook salmon to extinction remains linked to the elimination of access to most of their historical spawning grounds and the reduction of their population structure to a small population size. Recent trends in winter-run Chinook salmon abundance and cohort replacement are positive and may indicate some recovery since the listing. Although NMFS recently proposed that this ESU be upgraded from endangered to threatened status, it made the decision in its Final Listing Determination (June 28, 2005, 70 FR 37160) to continue to list the Sacramento River winter-run Chinook salmon ESU as endangered. This population remains below the recovery goals established for the run (NMFS 1997, 1998) and the naturally-spawned component of the ESU is dependent on one extant population in the Sacramento River. In general, the recovery criteria for winter-run Chinook salmon include a mean annual spawning abundance over any 13 consecutive years of at least 10,000 females with a concurrent geometric mean of the cohort replacement rate greater than 1.0.

d. *Population Trend – Central Valley Spring-run Chinook Salmon*

Historically, the predominant salmon run in the Central Valley was the spring-run Chinook salmon, which occupied the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud, and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFG 1998). Before the construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Construction of other low elevation dams in the foothills of the Sierras on the American, Mokelumne, Stanislaus, Tuolumne, and Merced Rivers extirpated Central Valley spring-run Chinook salmon from these watersheds. Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998).

On the Feather River, significant numbers of spring-run Chinook salmon, as identified by run timing, return to the FRH. In 2002, the FRH reported 4,189 returning spring-run Chinook salmon, which is 22 percent below the 10-year average of 4,727 fish. However, coded-wire tag (CWT) information from these hatchery returns indicates substantial introgression has occurred between fall-run and spring-run Chinook salmon populations within the Feather River system due to hatchery practices. Because Chinook salmon are not temporally separated in the hatchery, spring-run and fall-run Chinook salmon are spawned together, thus compromising the genetic integrity of the spring-run Chinook salmon stock. The number of naturally-spawning spring-run Chinook salmon in the Feather River has been estimated only periodically since the 1960s, with estimates ranging from 2 fish in 1978 to 2,908 in 1964. However, the genetic integrity of this population is questionable because of the significant temporal and spatial overlap between spawning populations of spring-run and fall-run Chinook salmon (Good *et al*. 2005). For the reasons discussed above, the Feather River spring-run Chinook population numbers are not included in the following discussion of ESU abundance.

Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993

(CDFG unpublished data). Even though the abundance of fish may increase from one year to the next, the overall average population trend has a negative slope during this time period (see Appendix B: Figure 3). The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2002 and 2003, total run size for the ESU was 13,218 and 8,775 adults respectively, well above the 1991 to 2001 average.

Evaluating the ESU as a whole masks significant changes that are occurring among basin metapopulations. For example, while the mainstem Sacramento River population has undergone a significant decline, the tributary populations have demonstrated substantial increases. The average population abundance of Sacramento River mainstem spring-run Chinook salmon has recently declined from a high of 12,107 fish for the period 1980 to 1990, to a low of 609 for the period between 1991 and 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same period. Although tributaries such as Mill and Deer Creeks have shown positive escapement trends since 1991, recent escapements to Butte Creek, including 20,259 in 1998, 9,605 in 2001, and 8,785 in 2002, are responsible for the overall increase in tributary abundance (CDFG 2002a, 2004b; CDFG, unpublished data). The Butte Creek estimates, which account for the majority of this ESU, do not include prespawning mortality. In the last several years as the Butte Creek population has increased, mortality of adult spawners has increased from 21 percent in 2002 to 60 percent in 2003 due to over-crowding and diseases associated with high water temperatures. This trend may indicate that the population in Butte Creek may have reached its carrying capacity (Ward *et al.* 2003) or has reached historical population levels (*i.e.*, Deer and Mill creeks). Table 4 shows the population trends from the three tributaries since 1986, including the 5-year moving average, cohort replacement rate, and estimated JPE.

Table 5. Spring-run Chinook salmon population estimates from CDFG Grand Tab (February 2005) with corresponding cohort replacement rates for years since 1986.

Year	Sacramento River Basin Escapement Run Size	5-Year Moving Average of Population Estimate	Cohort Replacement Rate	5-Year Moving Average of Cohort Replacement Rate	NMFS Calculated JPE[a]
1986	24,263	-	-	-	4,396,998
1987	12,675	-	-	-	2,296,993
1988	12,100	-	-	-	2,192,790
1989	7,085	-	0.29	-	1,283,960
1990	5,790	12,383	0.46	-	1,049,277
1991	1,623	7,855	0.13	-	294,124
1992	1,547	5,629	0.22	-	280,351
1993	1,403	3,490	0.24	0.27	254,255
1994	2,546	2,582	1.57	0.52	461,392
1995	9,824	3,389	6.35	1.70	1,780,328
1996	2,701	3,604	1.93	2.06	489,482
1997	1,431	3,581	0.56	2.13	259,329
1998	24,725	8,245	2.52	2.58	4,480,722

1999	6,069	8,950	2.25	2.72	1,099,838
2000	5,457	8,077	3.81	2.21	988,930
2001	13,326	10,202	0.54	1.94	2,414,969
2002	13,218	12,559	2.18	2.26	2,395,397
2003	8,902	9,394	1.63	2.08	1,613,241
2004	9,872	10,155	0.74	1.78	1,789,027
2005	14,312	11,926	1.08	1.23	2,593,654
median	7,994	9,172	1.33	1.74	1,448,601

[a]NMFS calculated the spring-run JPE using returning adult escapement numbers to the Sacramento River basin prior to the opening of the RBDD for spring-run migration, and then escapement to Mill, Deer, and Butte Creeks for the remaining period, and assuming a female to male ratio of 6:4 and prespawning mortality of 25 percent. NMFS utilized the female fecundity values in Fisher (1994) for spring-run Chinook salmon (4,900 eggs/female). The remaining survival estimates used the winter-run values for calculating JPE.

The extent of spring-run Chinook salmon spawning in the mainstem of the upper Sacramento River is unclear. Very few spring-run Chinook salmon redds (less than 15 per year) were observed from 1989 through 1993, and none in 1994, during aerial redd counts (FWS 2003a). Recently, the number of redds in September has varied from 29 to 105 during 2001 though 2003 depending on the number of survey flights (CDFG, unpublished data). In 2002, based on RBDD ladder counts, 485 spring-run Chinook salmon adults may have spawned in the mainstem Sacramento River or entered upstream tributaries such as Clear or Battle Creek (CDFG 2004b). In 2003, no adult spring-run Chinook salmon were believed to have spawned in the mainstem Sacramento River. Due to geographic overlap of ESU and resultant hybridization since the construction of Shasta Dam, Chinook salmon that spawn in the mainstem Sacramento River during September are more likely to be identified as early fall-run rather than spring-run Chinook salmon.

e. *Status of Spring-run Chinook Salmon*

The initial factors that led to the decline of spring-run Chinook salmon in the Central Valley were related to the loss of upstream habitat behind impassable dams. Since this initial loss of habitat, other factors have contributed to the instability of the spring-run Chinook salmon population and have negatively affected the ESU's ability to recover. These factors include a combination of physical, biological, and management factors such as climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and over-harvesting (CDFG 1998). Since spring-run Chinook salmon adults must hold over for months in small tributaries before spawning, they are much more susceptible to the effects of high water temperatures.

During the drought from 1986 to 1992, Central Valley spring-run Chinook salmon populations declined substantially. Reduced flows resulted in warm water temperatures that impacted adults, eggs, and juveniles. For adult spring-run Chinook salmon, reduced instream flows delayed or completely blocked access to holding and spawning habitats. Water management operations (*i.e.*, reservoir release schedules and volumes) and the unscreened and poorly screened diversions in the Sacramento River, Delta, and tributaries compounded drought-related problems by reducing river flows, elevating river temperatures, and entraining juveniles into the diversions.

Several actions have been taken to improve habitat conditions for spring-run Chinook salmon, including: improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts); implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries; and, changes in ocean and inland fishing regulations to minimize harvest. Although protective measures likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally-spawned and hatchery fish, run hybridization and genomic homogenization), climatic variation, high temperatures, predation, and water diversions still persist. Because the Central Valley spring-run Chinook salmon ESU is confined to relatively few remaining watersheds and continues to display broad fluctuations in abundance, the population is at a moderate risk of extinction.

2. <u>Steelhead</u>

a. *General Life History*

Steelhead can be divided into two life history types, based on their state of sexual maturity at the time of river entry and the duration of their spawning migration, stream-maturing and ocean-maturing. Stream-maturing steelhead enter freshwater in a sexually immature condition and require several months to mature and spawn, whereas ocean-maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. These two life history types are more commonly referred to by their season of freshwater entry (*i.e.,* summer (stream-maturing) and winter (ocean-maturing) steelhead). Only winter steelhead currently are found in Central Valley rivers and streams (McEwan and Jackson 1996), although there are indications that summer steelhead were present in the Sacramento river system prior to the commencement of large-scale dam construction in the 1940s (Interagency Ecological Program [IEP] Steelhead Project Work Team 1999). At present, summer steelhead are found only in North Coast drainages, mostly in tributaries of the Eel, Klamath, and Trinity River systems (McEwan and Jackson 1996).

Winter steelhead generally leave the ocean from August through April, and spawn between December and May (Busby *et al.* 1996). Timing of upstream migration is correlated with higher flow events, such as freshets or sand bar breaches, and associated lower water temperatures. In general, the preferred water temperature for adult steelhead migration is 46 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). Thermal stress may occur at temperatures beginning at 66 ^{o}F and mortality has been demonstrated at temperatures beginning at 70 ^{o}F, although some races of steelhead may have higher or lower temperature tolerances depending upon their evolutionary history. Lower latitudes and elevations would tend to favor fish tolerant of higher ambient temperatures (see Matthews and Berg (1997) for discussion of *O. mykiss* from Sespe Creek in Southern California). The preferred water temperature for steelhead spawning is 39 ^{o}F to 52 ^{o}F, and the preferred water temperature for steelhead egg incubation is 48 ^{o}F to 52 ^{o}F (McEwan and Jackson 1996, Myrick 1998, Myrick and Cech 2000). The minimum stream depth necessary for successful upstream migration is 13 cm (Thompson 1972). Preferred water velocity for upstream migration is in the range of 40-90 cm/s, with a maximum velocity, beyond which upstream migration is not likely to occur, of 240 cm/s (Thompson 1972, Smith 1973).

Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996). However, it is rare for steelhead to spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992, Busby *et al.* 1996). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996). Although one-time spawners are the great majority, Shapovalov and Taft (1954) reported that repeat spawners are relatively numerous (17.2 percent) in California streams. Most steelhead spawning takes place from late December through April, with peaks from January though March (Hallock *et al.* 1961). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity, and may spawn in intermittent streams as well (Everest 1973, Barnhart 1986).

The length of the incubation period for steelhead eggs is dependent on water temperature, DO concentration, and substrate composition. In late spring, following yolk sac absorption, fry emerge from the gravel and actively begin feeding in shallow water along stream banks (Nickelson *et al.* 1992).

Steelhead rearing during the summer takes place primarily in higher velocity areas in pools, although young-of-the-year also are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Productive steelhead habitat is characterized by complexity, primarily in the form of large and small woody debris. Cover is an important habitat component for juvenile steelhead both as velocity refugia and as a means of avoiding predation (Shirvell 1990, Meehan and Bjornn 1991). Some older juveniles move downstream to rear in large tributaries and mainstem rivers (Nickelson *et al.* 1992). Juveniles feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey upon emerging fry.

Steelhead generally spend 2 years in freshwater before emigrating downstream (Hallock *et al.* 1961, Hallock 1989). Rearing steelhead juveniles prefer water temperatures of 45 EF to 58 EF and have an upper lethal limit of 75 EF. They can survive up to 81 EF with saturated DO conditions and a plentiful food supply. Reiser and Bjornn (1979) recommended that DO concentrations remain at or near saturation levels with temporary reductions no lower than 5.0 mg/l for successful rearing of juvenile steelhead. During rearing, suspended and deposited fine sediments can directly affect salmonids by abrading and clogging gills, and indirectly cause reduced feeding, avoidance reactions, destruction of food supplies, reduced egg and alevin survival, and changed rearing habitat (Reiser and Bjornn 1979). Bell (1973) found that silt loads of less than 25 mg/l permit good rearing conditions for juvenile salmonids.

Juvenile steelhead emigrate episodically from natal streams during fall, winter, and spring high flows. Emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the sea. Barnhart (1986) reported that steelhead smolts in California range in size from 140 to 210 mm (fork length). Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River basin migrate downstream during most months of the year, but the peak period of emigration occurred in the spring, with a much smaller peak in the fall.

b. *Population Trend – Central Valley Steelhead*

Steelhead historically were well-distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessable due to Shasta and Keswick Dams) south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alterations from numerous water diversion projects) and in both east and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). The California Advisory Committee on Salmon and Steelhead (1988) reported a reduction of steelhead habitat from 6,000 miles historically to 300 miles currently. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996).

Historic Central Valley steelhead run sizes are difficult to estimate given the paucity of data, but may have approached 1 to 2 million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally-spawned steelhead populations in the upper Sacramento River have declined substantially (see Appendix B: Figure 4). Hallock *et al.* (1961) estimated an average of 20,540 adult steelhead through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at the RBDD declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

Nobriga and Cadrett (2003) compared CWT and untagged (wild) steelhead smolt catch ratios at Chipps Island trawl from 1998 through 2001 to estimate that about 100,000 to 300,000 steelhead juveniles are produced naturally each year in the Central Valley. In the draft *Updated Status Review of West Coast Salmon and Steelhead* (NMFS 2003), the Biological Review Team (BRT) made the following conclusion based on the Chipps Island data:

> "If we make the fairly generous assumptions (in the sense of generating large estimates of spawners) that average fecundity is 5,000 eggs per female, 1 percent of eggs survive to reach Chipps Island, and 181,000 smolts are produced (the 1998-2000 average), about 3,628 female steelhead spawn naturally in the entire Central Valley. This can be compared with McEwan's (2001) estimate of 1 million to 2 million spawners before 1850, and 40,000 spawners in the 1960s".

The only consistent data available on steelhead numbers in the San Joaquin River basin come from CDFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale.

These data (see Appendix B, Figure 5) indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (CDFG 2003). In 2003, a total of 12 steelhead smolts were collected at Mossdale (CDFG, unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, as reported in Good *et al*. 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be devoid of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (Demko *et al.* 2000). After 3 years of operating a fish counting weir on the Stanislaus River only two adult steelhead have been observed moving upstream, although several large rainbow trout (*O. mykiss*) have washed up on the weir in late winter (S.P. Cramer 2005). It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that steelhead are widespread, if not abundant, throughout accessible streams and rivers in the Central Valley (Good *et al*. 2005).

c. *Status - Central Valley Steelhead*

Both the BRT (Good *et al*. 2005) and the Artificial Propagation Evaluation Workshop (69 FR 33102) concluded that the Central Valley steelhead DPS presently is "in danger of extinction". Steelhead have been extirpated from most of their historical range in this region. Habitat concerns in this DPS focus on the widespread degradation, destruction, and blockage of freshwater habitat within the region, and water allocation problems. Widespread hatchery steelhead production within this DPS also raises concerns about the potential ecological interactions between introduced stocks and native stocks. Because the Central Valley steelhead population has been fragmented into smaller isolated tributaries without any large source population and the remaining habitat continues to be degraded by water diversions, the population remains at an elevated risk for future population declines.

3. <u>Southern Distinct Population Segment of North American Green Sturgeon</u>

a. *General Life History*

(1) *Adult Distribution and Feeding*. In North America, spawning populations of the anadromous green sturgeon currently are found in only three river systems, the Sacramento and

Klamath Rivers in California and the Rogue River in southern Oregon. Spawning has only been reported in one Asian river, the Tumin River in eastern Asia. Green sturgeon are known to range from Baja California to the Bering Sea along the North American continental shelf. Data from commercial trawl fisheries and tagging studies indicate that the green sturgeon occupy waters within the 110 meter contour (NMFS 2005a). During the late summer and early fall, subadults and nonspawning adult green sturgeon frequently can be found aggregating in estuaries along the Pacific coast (Emmett *et al.* 1991). Particularly large concentrations occur in the Columbia River estuary, Willapa Bay, and Grays Harbor, with smaller aggregations in San Francisco and San Pablo Bays (Emmett *et* al 1991, Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Recent acoustical tagging studies on the Rogue River (Erickson *et al.* 2002) have shown that adult green sturgeon will hold for as long as 6 months in deep (> 5m), low gradient reaches, off channel sloughs or coves of the river during summer months when water temperatures were between 15 ^{o}C and 23 ^{o}C. When ambient temperatures in the river dropped in autumn and early winter (< 10 ^{o}C) and flows increased, fish moved downstream and into the ocean.

Adult green sturgeon are believed to feed primarily upon benthic invertebrates such as clams, mysid and grass shrimp, and amphipods (Radtke 1966, J. Stuart, NMFS, pers. obs., unpublished data). Adult sturgeon caught in Washington state waters were found to have fed on Pacific sand lance (*Ammodytes hexapterus*) and callianassid shrimp (Moyle *et al.* 1992).

(2) *Spawning*. Adult green sturgeon are believed to spawn every 3 to 5 years and reach sexual maturity only after several years of growth (10 to 15 years based on sympatric white sturgeon (*A. transmontanus*) sexual maturity). Adult female green sturgeon produce between 60,000 and 140,000 eggs, depending on body size, with a mean egg diameter of 4.3 mm (Moyle *et al.* 1992, Van Eenennaam *et al.* 2001). They have the largest egg size of any sturgeon, and the volume of yolk ensures an ample supply of energy for the developing embryo. The eggs are less adhesive and more dense than than those of white sturgeon (Kynard *et al.* 2005). Green sturgeon adults begin their upstream spawning migrations into freshwater in late February with spawning occuring between March and July. Peak spawning is believed to occur between April and June in deep, turbulent, mainstem channels over large cobble and rocky substrates with crevices and interstices. Females broadcast spawn their eggs over this substrate, and the fertilized eggs sink into the interstices of the substrate where they develop further (Kynard *et al.* 2005).

(3) *Egg Development.* Green sturgeon larvae hatched from fertilized eggs after approximately 169 hours at a water temperature of 15 ^{o}C (Van Eenennaam *et al.* 2001, Deng *et al.* 2002), which is similar to the sympatric white sturgeon development rate (176 hours). Van Eenennaam *et al.* (2005) indicated that an optimum range of water temperature for egg development ranged between 14 ^{o}C and 17 ^{o}C. Temperatures over 23 ^{o}C resulted in 100 percent mortality of fertilized eggs before hatching. Eggs incubated at water temperatures between 17.5 ^{o}C and 22 ^{o}C resulted in elevated mortalities and an increased occurrence of morphological abnormalities in those eggs that did hatch. At incubation temperatures below 14 ^{o}C, hatching mortality also increased significantly, and morphological abnormalities increased slightly, but not statistically so.

(4) *Early Development.* Newly hatched green sturgeon are approximately 12.5 to 14.5 mm in length and have a large ovoid yolk sac that supplies nutritional energy until exogenous feeding occurs. The larvae are less developed in their morphology than older juveniles and external morphology resembles a "tadpole" with a continuous fin fold on both the dorsal and ventral sides of the caudal trunk. The eyes are well developed with differentiated lenses and pigmentation. Olfactory and auditory vesicles are present while the mouth and respiratory structures are only shallow clefts on the head. At 10 days of age, the yolk sac has become greatly reduced in size and the larvae initiates exogenous feeding through a functional mouth. The fin folds have become more developed and formation of fin rays begins to occur in all fin tissues. By 45 days of age, the green sturgeon larvae have completed their metamorphosis, which is characterized by the development of dorsal, lateral, and ventral scutes, elongation of the barbels, rostrum, and caudal peduncle, reabsorption of the caudal and ventral fin folds, and the development of fin rays. The juvenile fish resembles the adult form, including the dark olive coloring, with a dark mid-ventral stripe (Deng *et al.* 2002).

Green sturgeon larvae do not exhibit the initial pelagic swim-up behavior characteristic of other A*cipenseridae*. They are strongly oriented to the bottom and exhibit nocturnal activity patterns. After 6 days, the larvae exhibit nocturnal swim-up activity (Deng *et al.* 2002) and nocturnal downstream migrational movements (Kynard *et al.* 2005). Juvenile fish continue to exhibit nocturnal behavioral beyond the metamorphosis from larvae to juvenile stages. Kynard *et al.*'s (2005) laboratory studies indicated that juvenile fish continued to migrate downstream at night for the first 6 months of life. When ambient water temperatures reached 8 ^{o}C, downstream migrational behavior diminished and holding behavior increased. This data suggests that 9- to 10- month old fish would hold over in their natal rivers during the ensuing winter following hatching, but at a location downstream of their spawning grounds.

Green sturgeon juveniles tested under laboratory conditions had optimal bioenergetic performance (*i.e.*, growth, food conversion, swimming ability) between 15 ^{o}C and 19 ^{o}C under either full or reduced rations (Mayfield and Cech 2004). This temperature range overlaps the egg incubation temperature range for peak hatching success previously discussed. Ambient water temperature conditions in the Rogue and Klamath River systems range from 4 ^{o}C to approximately 24 ^{o}C. The Sacramento River has similar temperature profiles, and, like the Rogue and Klamath Rivers, is a regulated system with several dams controlling flows on its mainstem (Shasta and Keswick Dams), and its tributaries (Whiskeytown, Oroville, Folsom, and Nimbus Dams).

Larval and juvenile green sturgeon are subject to predation by both native and introduced fish species. Smallmouth bass (*Micropterus dolomieui*) have been recorded on the Rogue River as preying on juvenile green sturgeon, and prickly sculpin (*Cottus asper*) have been shown to be an effective predator on the larvae of sympatric white sturgeon (Gadomski and Parsley 2005). This latter study also indicated that the lowered turbidity found in tailwater streams and rivers due to dams increased the effectiveness of sculpin predation on sturgeon larvae under laboratory conditions.

b. *Population Trend –Southern Distinct Population Segment of North American Green Sturgeon*

Based on the distribution of sturgeon eggs, larvae, and juveniles the in the Sacramento River, CDFG (2002c) indicated that southern DPS of green sturgeon spawn in late-spring and early-summer above Hamilton City possibly to Keswick Dam. Young green sturgeon appear to rear for the first 1 to 2 months in the Sacramento River between Keswick Dam and Hamilton City (CDFG 2002c). Juvenile green sturgeon first appear in FWS sampling efforts at RBDD in June and July at lengths ranging in fork length from 24 to 31 mm (CDFG 2002c). Sampling efforts at Glen Colusa Irrigation District on the Sacramento River yield green sturgeons averaging approximately 29 mm in length with a peak abundance occurring in July (Adams *et al.* 2002). Since 1980, trawling studies in the San Francisco Bay estuary and Delta have taken a total of 61 juvenile green sturgeon ranging in size from 20 to 112 cm total length and although most juveniles are captured between April and October, they have been captured in nearly every month of the year (CDFG 2002c, IEP Relational Database search May 31, 2005). Juveniles spend between 1 and 4 years in fresh and estuarine waters and enter the marine environment at lengths of approximately 300 mm (Adams *et al.* 2002).

Spawning in the Feather River is suspected to have occurred in the past due to the continued presence of adult green sturgeon in the river below Oroville Dam. This continued presence of adults below the dam suggests that fish are trying to migrate upstream to spawning areas now blocked by the dam, which was constructed in 1968. Due to the extreme longevity of green sturgeon (and sturgeon in general), it is possible that these adults represent adults which have previously spawned in the Feather River system prior to the construction of the dam.

Spawning in the San Joaquin River system has not been recorded, but alterations of the San Joaquin River tributaries (Stanislaus, Tuolumne, and Merced Rivers) and its mainstem occurred early in the European settlement of the region. During the later half of the 1800s impassable barriers were built on these tributaries where the water courses left the foothills and entered the valley floor. Therefore, these low elevation dams have blocked potentially suitable spawning habitats located further upstream for over a century. Additional destruction of riparian and stream channel habitat by industrialized gold dredging further disturbed any valley floor habitat that was still available for sturgeon spawning. It is likely that both white and green sturgeon utilized the San Joaquin River basin for spawning prior to the onset of European influence, based on past use of the region by populations of Central Valley spring-run Chinook salmon and Central Valley steelhead. These two populations of salmonids have either been extirpated or greatly diminished in their use of the San Joaquin River basin over the past two centuries.

Population abundance information concerning the southern DPS of North American green sturgeon is scant as described in the status review (Adams 2002). Limited population abundance information comes from incidental captures of green sturgeon from the white sturgeon monitoring program by the CDFG sturgeon tagging program (CDFG 2002c). CDFG (2002c) utilizes a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable. Fish monitoring efforts at RBDD and GCID on the upper Sacramento River have captured between 0 and 2,068 juvenile green sturgeon per year, mostly between June and July (Adams 2002). The only existing information regarding changes in the abundance of the southern DPS of green sturgeon includes changes in their abundance at the John Skinner Fish Protection Facility between 1968 and 2001 (SWP facility). The estimated number of green sturgeon taken at the SWP facility prior to 1986 was 732; since 1986, the average number has dropped to 47 (70 FR 17386). For the Tracy Fish Collection Facility (CVP facility), the average number prior to 1986 was 889; from 1986 to 2001 the average has dropped to 32 (70 FR 17386). In light of the increased volume of water exports, particularly during the previous 10 years, it is apparent that green sturgeon population abundance is dropping. Catches of sub-adult and adult green sturgeon by the IEP between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the proportion of the southern DPS of North American green sturgeon is unknown due to the comingling of the Northern and Southern population segments in San Pablo Bay. Additional analysis of green and white sturgeon taken at the SWP and CVP facilities indicates that take of both green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960s (70 FR 17386).

c. *Status –Southern Distinct Population Segment of North American Green Sturgeon*

The southern DPS of North American green sturgeon historically was smaller than the sympatric population of white sturgeon in the San Francisco Bay estuary and its associated tributaries. The population has apparently been declining over the past several decades based on harvest numbers from sport and commercial fisheries and the entrainment rates at the CVP and SWP. The principle factor for this decline is the reduction of green sturgeon spawning habitat to a limited area below Keswick Dam on the Sacramento River. The construction of impassable barriers, particularly large dams, has greatly reduced the access of green sturgeon to their historical spawning areas. Reduced flows have corresponded with weakened year class recruitment in the sympatric white sturgeon population and it is believed to have the same effect upon green sturgeon recruitment. In addition to the adverse effects of impassable barriers, numerous agricultural water diversions exist in the Sacramento River and the Delta along the migratory route of larval and juvenile sturgeon. Entrainment, or, if equipped with a fish screen, impingement are considered serious threats to sturgeon during their downstream migration. Fish screens have not been designed with criteria that address sturgeon behavior or swimming capabilities. The benthic oriented sturgeon are also more susceptible to contaminated sediments through dermal contact and through their feeding behavior of ingesting prey along with contaminated sediments before winnowing out the sediment. Their long life spans allow them to accumulate high body burdens of contaminants, that potentially will reach concentrations with deleterious physiological effects. All of the above threats have been identified by the BRT as potentially affecting the continued existence of the southern DPS of North American green strurgeon (70 FR 17386).

C. Factors Affecting the Species and Critical Habitat

A number of documents have addressed the history of human activities, present environmental conditions, and factors contributing to the decline of salmon and steelhead species in the Central Valley. For example, NMFS prepared range-wide status reviews for West coast Chinook salmon (Myers *et al.* 1998), steelhead (Busby *et al.* 1996) and green sturgeon (Adams *et al.* 2002, NMFS 2005a). Also, the NMFS BRT published a draft updated status review for West coast Chinook salmon and steelhead in November 2003 (NMFS 2003) and a final review in June 2005 (Good *et* *al.* 2005). Information also is available in Federal Register notices announcing ESA listing proposals and determinations for some of these species and their critical habitat (*e.g.*, 58 FR 33212, 59 FR 440, 62 FR 24588, 62 FR 43937, 63 FR 13347, 64 FR 24049, 64 FR 50394, 65 FR 7764). The Final Programmatic Environmental Impact Statement/Report (EIS/EIR) for the CALFED Bay-Delta Program (CALFED 1999), and the Final Programmatic EIS for the CVPIA (Department of Interior (DOI) 1999), provide an excellent summary of historical and recent environmental conditions for salmon and steelhead in the Central Valley.

The following general description of the factors affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, the southern DPS of North American green sturgeon, and their habitat is based on a summary of these documents.

In general, the human activities that have affected listed anadromous salmonids, proposed North American green sturgeon, or their habitats consist of: (1) dam construction that blocks previously accessible habitat; (2) water development and management activities that affect water quantity, flow timing, quality, and stream function; (3) land use activities such as agriculture, flood control, urban development, mining, road construction, and logging that degrade aquatic and riparian habitat; (4) hatchery operation and practices; (5) harvest activities; and, (6) ecosystem restoration actions.

1. <u>Habitat Blockage</u>

Hydropower, flood control, and water supply dams of the CVP, SWP, and other municipal and private entities permanently have blocked or hindered salmonid access to historical spawning and rearing grounds. Clark (1929) estimated that originally there were 6,000 linear miles of salmon habitat in the Central Valley system and that 80 percent of this habitat had been lost by 1928. Yoshiyama *et al.* (1996) calculated that roughly 2,000 linear miles of salmon habitat was actually available before dam construction and mining, and concluded that 82 percent is not accessible today.

In general, large dams on every major tributary to the Sacramento River, San Joaquin River, and the Delta block salmon and steelhead access to the upper portions of their respective watersheds. On the Sacramento River, Keswick Dam blocks passage to historic spawning and rearing habitat in the upper Sacramento, McCloud, and Pit Rivers. Whiskeytown Dam blocks access to the upper watershed of Clear Creek. Oroville Dam and associated facilities block passage to the upper Feather River watershed. Nimbus Dam blocks access to most of the American River basin. Friant Dam construction in the mid-1940s has been associated with the elimination of spring-run Chinook salmon in the San Joaquin River upstream of the Merced River (Department of Interior [DOI] 1999). On the Stanislaus River, construction of Goodwin Dam (1912), Tulloch Dam (1957), and New Melones Dam (1979) blocked both spring- and fall-run Chinook salmon (CDFG 2001) as well as Central Valley steelhead. Similarly, La Grange Dam (1893) and New Don Pedro Dam (1971) blocked upstream access to salmonids on the Tuolumne River. Upstream migration on the Merced River was blocked in 1910 by the construction of Merced Falls and Crocker-Huffman Dams and later New Exchequer Dam (1967) and McSwain Dam (1967). These dams also had the potential to block any spawning populations of green sturgeon in these tributaries.

As a result of the dams, winter-run Chinook salmon, spring-run Chinook salmon, and steelhead populations on these rivers have been confined to lower elevation mainstems that historically only were used for migration. Population abundances have declined in these streams due to decreased quantity and quality of spawning and rearing habitat. Higher temperatures at these lower elevations during late-summer and fall are a major stressor to adults and juvenile salmonids. Green sturgeon populations would be similarly affected by these barriers and alterations to the natural hydrology.

The Suisun Marsh Salinity Control Gates (SMSCG), located on Montezuma Slough, were installed in 1988, and are operated with gates and flashboards to decrease the salinity levels of managed wetlands in Suisun Marsh. The SMSCG have delayed or blocked passage of adult Chinook salmon migrating upstream (Edwards *et al.* 1996, Tillman *et al.* 1996, California Department of Water Resources (DWR) 2002). The effects of the SMSCG on sturgeon are unknown at this time.

2. Water Development

The diversion and storage of natural flows by dams and diversion structures on Central Valley waterways have depleted streamflows and altered the natural cycles by which juvenile and adult salmonids base their migrations. As much as 60 percent of the natural historical inflow to Central Valley watersheds and the Delta has been diverted for human uses. Depleted flows have contributed to higher temperatures, lower DO levels, and decreased recruitment of gravel and large woody debris (LWD). More uniform flows year-round have resulted in diminished natural channel formation, altered foodweb processes, and slower regeneration of riparian vegetation. These stable flow patterns have reduced bedload movement (Mount 1995, Ayers 2001), caused spawning gravels to become embedded, and decreased channel widths due to channel incision, all of which has decreased the available spawning and rearing habitat below dams.

Water diversions for irrigated agriculture, municipal and industrial use, and managed wetlands are found throughout the Central Valley. Hundreds of small and medium-size water diversions exist along the Sacramento River, San Joaquin River, and their tributaries. Although efforts have been made in recent years to screen some of these diversions, many remain unscreened. Depending on the size, location, and season of operation, these unscreened diversions entrain and kill many life stages of aquatic species, including juvenile salmonids. For example, as of 1997, 98.5 percent of the 3,356 diversions included in a Central Valley database were either unscreened or screened insufficiently to prevent fish entrainment (Herren and Kawasaki 2001). Most of the 370 water diversions operating in Suisun Marsh are unscreened (FWS 2003b).

Outmigrant juvenile salmonids in the Delta have been subjected to adverse environmental conditions created by water export operations at the CVP/SWP. Specifically, juvenile salmonid survival has been reduced by the following: (1) water diversion from the mainstem Sacramento River into the Central Delta via the Delta Cross Channel; (2) upstream or reverse flows of water in the lower San Joaquin River and southern Delta waterways; (3) entrainment at the CVP/SWP export facilities and associated problems at Clifton Court Forebay; and, (4) increased exposure to introduced, non-native predators such as striped bass (*Morone saxatilis*), largemouth bass

(*Micropterus salmoides*), and sunfishes (*Centrarchidae* spp.). Entrainment of green sturgeon at the CVP/SWP export facility is known to occur as well.

3. Land Use Activities

Land use activities continue to have large impacts on salmonid habitat in the Central Valley watershed. Until about 150 years ago, the Sacramento River was bordered by up to 500,000 acres of riparian forest, with bands of vegetation extending outward for 4 or 5 miles (California Resources Agency 1989). By 1979, riparian habitat along the Sacramento River diminished to 11,000 to 12,000 acres, or about 2 percent of historic levels (McGill 1987). The degradation and fragmentation of riparian habitat had resulted mainly from flood control and bank protection projects, together with the conversion of riparian land to agriculture. Removal of snags and driftwood in the Sacramento and San Joaquin River basins has reduced sources of LWD needed to form and maintain stream habitat that salmon depend on for various life stages.

Increased sedimentation resulting from agricultural and urban practices within the Central Valley is a primary cause of salmonid habitat degradation (NMFS 1996). Sedimentation can adversely affect salmonids during all freshwater life stages by: clogging or abrading gill surfaces, adhering to eggs, hampering fry emergence (Phillips and Campbell 1961), burying eggs or alevins, scouring and filling in pools and riffles, reducing primary productivity and photosynthesis activity (Cordone and Kelley 1961), and affecting intergravel permeability and DO levels. Excessive sedimentation over time can cause substrates to become embedded, which reduces successful salmonid spawning and egg and fry survival (Waters 1995).

Land use activities associated with road construction, urban development, logging, mining, agriculture, and recreation have significantly altered fish habitat quantity and quality through the alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and, removal of riparian vegetation, resulting in increased streambank erosion (Meehan 1991). Urban stormwater and agricultural runoff may be contaminated with herbicides and pesticides, petroleum products, sediment, *etc.* Agricultural practices in the Central Valley have eliminated large trees and logs and other woody debris that would otherwise be recruited into the stream channel (NMFS 1998). LWD influences stream morphology by affecting channel pattern, position, and geometry, as well as pool formation (Keller and Swanson 1979, Bilby 1984, Robison and Beschta 1990).

Since the 1850s, wetlands reclamation for urban and agricultural development has caused the cumulative loss of 79 and 94 percent of the tidal marsh habitat in the Delta downstream and upstream of Chipps Island, respectively (Conomos *et al.* 1985, Nichols *et al.* 1986, Wright and Phillips 1988, Monroe *et al.* 1992, Goals Project 1999). Prior to 1850, approximately 1400 km^2 of freshwater marsh surrounded the confluence of the Sacramento and San Joaquin Rivers, and another 800 km^2 of saltwater marsh fringed San Francisco Bay's margins. Of the original 2,200 km^2 of tidally influenced marsh, only about 125 km^2 of undiked marsh remains today. In Suisun Marsh, saltwater intrusion and land subsidence gradually has led to the decline of agricultural production. Presently, Suisun Marsh consists largely of tidal sloughs and managed wetlands for duck clubs, which first were established in the 1870s in western Suisun Marsh (Goals Project 1999).

Dredging of river channels to enhance inland maritime trade and to provide raw material for levee construction has significantly and detrimentally altered the natural hydrology and function of the river systems in the Central Valley.

Juvenile salmonids are exposed to increased water temperatures in the Delta during the late spring and summer due to the loss of riparian shading, and by thermal inputs from municipal, industrial, and agricultural discharges. Studies by DWR on water quality in the Delta over the last 30 years have shown a steady decline in the food sources available for juvenile salmonids and sturgeon and an increase in the clarity of the water due to a decline in the phytoplankton and zooplankton abundance. These conditions have contributed to increased mortality of juvenile Chinook salmon, steelhead, and sturgeon as they move through the Delta.

4. Water Quality

The water quality of the Delta has been negatively impacted over the last 150 years. Increased water temperatures, decreased DO levels, and increased turbidity and contaminant loads have degraded the quality of the aquatic habitat for the rearing and migration of salmonids. The Regional Board, in its 1998 Clean Water Act §303(d) list characterized the Delta as an impaired waterbody having elevated levels of chlorpyrifos, dichlorodiphenyltrichlor (*i.e.* DDT), diazinon, electrical conductivity, Group A pesticides (aldrin, dieldrin, chlordane, endrin, heptachlor, heptachlor epoxide, hexachlorocyclohexane (including lindane), endosulfan and toxaphene), mercury, low DO, organic enrichment, and unknown toxicities (Regional Board 1998, 2001).

In general, water degradation or contamination can lead to either acute toxicity, resulting in death when concentrations are sufficiently elevated, or more typically, when concentrations are lower, to chronic or sublethal effects that reduce the physical health of the organism, and lessens its survival over an extended period of time. Mortality may become a secondary effect due to compromised physiology or behavioral changes that lessen the organism's ability to carry out its normal activities. For example, increased levels of heavy metals are detrimental to the health of an organism because they: interfere with metabolic functions by inhibiting key enzyme activity in metabolic pathways; decrease neurological function; degrade cardiovascular output; and act as mutagens, teratogens or carcinogens in exposed organisms (Rand *et al.* 1995, Goyer 1996). For listed species, these effects may occur directly to the listed fish or to its prey base, which reduces the forage base available to the listed species.

Sediments can either act as a sink or as a source of contamination depending on hydrological conditions and the type of habitat the sediment occurs in. Sediment provides habitat for many aquatic organisms and is a major repository for many of the more persistent chemicals that are introduced into the surface waters. In the aquatic environment, most anthropogenic chemicals and waste materials including toxic organic and inorganic chemicals eventually accumulate in sediment (Ingersoll 1995).

Direct exposure to contaminated sediments may cause deleterious effects to listed salmonids or the proposed threatened green sturgeon. This may occur if a fish swims through a plume of the resuspended sediments or rests on contaminated substrate and absorbs the toxic compounds through one of several routes: dermal contact, ingestion, or uptake across the gills. Elevated contaminant levels may be found in localized "hot spots" where discharge occurs or where river currents deposit sediment loads. Sediment contaminant levels can thus be significantly higher than the overlying water column concentrations (EPA 1994). However, the more likely route of exposure to salmonids or sturgeon is through the food chain, when the fish feed on organisms that are contaminated with toxic compounds. Prey species become contaminated either by feeding on the detritus associated with the sediments or dwelling in the sediment itself. Therefore, the degree of exposure to the salmonids depends on their trophic level and the amount of contaminated forage base they consume. Response of salmonids to contaminated sediments is similar to water borne exposures.

5. Hatchery Operations and Practices

Five hatcheries currently produce Chinook salmon in the Central Valley and four of these also produce steelhead. Releasing large numbers of hatchery fish can pose a threat to wild Chinook salmon and steelhead stocks through genetic impacts, competition for food and other resources between hatchery and wild fish, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991). The genetic impacts of artificial propagation programs in the Central Valley primarily are caused by straying of hatchery fish and the subsequent interbreeding of hatchery fish with wild fish. In the Central Valley, practices such as transferring eggs between hatcheries and trucking smolts to distant sites for release contribute to elevated straying levels (DOI 1999). For example, Nimbus Hatchery on the American River rears Eel River steelhead stock and releases these fish in the Sacramento River basin. One of the recommendations in the Joint Hatchery Review Report (NMFS and CDFG 2001) was to identify and designate new sources of steelhead brood stock to replace the current Eel River origin brood stock.

Hatchery practices as well as spatial and temporal overlaps of habitat use and spawning activity between spring- and fall-run fish have led to the hybridization and homogenization of some subpopulations (CDFG 1998). As early as the 1960s, Slater (1963) observed that early fall- and spring-run Chinook salmon were competing for spawning sites in the Sacramento River below Keswick Dam, and speculated that the two runs may have hybridized. The FRH spring-run Chinook salmon have been documented as straying throughout the Central Valley for many years (CDFG 1998), and in many cases have been recovered from the spawning grounds of fall-run Chinook salmon, an indication that FRH spring-run Chinook salmon may exhibit fall-run life history characteristics. Although the degree of hybridization has not been comprehensively determined, it is clear that the populations of spring-run Chinook salmon spawning in the Feather River and counted at RBDD contain hybridized fish.

The management of hatcheries, such as Nimbus Hatchery and FRH, can directly impact spring-run Chinook salmon and steelhead populations by oversaturating the natural carrying capacity of the limited habitat available below dams. In the case of the Feather River, significant redd superimposition occurs in-river due to hatchery overproduction and the inability to physically separate spring- and fall-run Chinook salmon adults. This concurrent spawning has led to hybridization between the spring- and fall-run Chinook salmon in the Feather River. At Nimbus Hatchery, operating Folsom Dam to meet temperature requirements for returning hatchery fall-run Chinook salmon often limits the amount if water available for steelhead spawning and rearing the rest of the year.

The increase in Central Valley hatchery production has reversed the composition of the steelhead population, from 88 percent naturally produced fish in the 1950s (McEwan 2001) to an estimated 23 to 37 percent naturally produced fish currently (Nobriga and Cadrett 2001). The increase in hatchery steelhead production proportionate to the wild population has reduced the viability of the wild steelhead populations, increased the use of out-of-basin stocks for hatchery production, and increased straying (NMFS and CDFG 2001). Thus, the ability of natural populations to successfully reproduce and continue their genetic integrity likely has been diminished.

The relatively low number of spawners needed to sustain a hatchery population can result in high harvest-to-escapements ratios in waters where fishing regulations are set according to hatchery population. This can lead to over-exploitation and reduction in the size of wild populations existing in the same system as hatchery populations due to incidental bycatch (McEwan 2001).

Hatcheries also can have some positive effects on salmonid populations. Artificial propagation has been shown to be effective in bolstering the numbers of naturally spawning fish in the short term under specific scenarios, artificial propagation programs can also aid in conserving genetic resources and guarding against catastrophic loss of naturally-spawned populations at critically low abundance levels, as was the case with the Sacramento River winter-run Chinook salmon population during the 1990s. However, relative abundance is only one component of a viable salmonid population.

6. <u>Commercial and Sport Harvest</u>

a. *Ocean Harvest*

(1) *Chinook salmon*. Extensive ocean recreational and commercial troll fisheries for Chinook salmon exist along the Central California coast, and an inland recreational fishery exists in the Central Valley for Chinook salmon and steelhead. Ocean harvest of Central Valley Chinook salmon is estimated using an abundance index, called the Central Valley Index (CVI). The CVI is the ratio of Chinook salmon harvested south of Point Arena (where 85 percent of Central Valley Chinook salmon are caught) to escapement. CWT returns indicate that Sacramento River salmon congregate off the California coast between Point Arena and Morro Bay.

Since 1970, the CVI for winter-run Chinook salmon generally has ranged between 0.50 and 0.80. In 1990, when ocean harvest of winter-run Chinook salmon was first evaluated by NMFS and the Pacific Fisheries Management Council (PFMC), the CVI harvest rate was near the highest recorded level at 0.79. NMFS determined in a 1991 biological opinion that continuance of the 1990 ocean harvest rate would not prevent the recovery of winter-run Chinook salmon. Through the early 1990s, the ocean harvest index was below the 1990 level (*i.e.*, 0.71 in 1991 and 1992, 0.72 in 1993, 0.74 in 1994, 0.78 in 1995, and 0.64 in 1996). In 1996 and 1997, NMFS issued a biological opinion which concluded that incidental ocean harvest of winter-run Chinook salmon represented a significant source of mortality to the endangered population, even though ocean harvest was not a key factor leading to the decline of the population. As a result of these opinions, measures were developed and implemented by the PFMC, NMFS, and CDFG to reduce ocean harvest by approximately 50 percent.

Ocean fisheries have affected the age structure of spring-run Chinook salmon through targeting large fish for many years and reducing the numbers of 4- and 5-year-old fish (CDFG 1998). There are limited data on spring-run Chinook salmon ocean harvest rates. An analysis of 6 tagged groups of FRH spring-run Chinook salmon by Cramer and Demko (1997) indicated that harvest rates of 3-year-old fish ranged from 18 percent to 22 percent, 4-year-old fish ranged from 57 percent to 84 percent, and 5-year-olds ranged from 97 percent to 100 percent. The almost complete removal of 5-year-olds from the population effectively reduces the age structure of the species, which reduces its resiliency to factors that may impact a particular year class (*e.g.*, prespawning mortality from lethal instream water temperatures).

(2) *Steelhead.* There is essentially no ocean harvest of steelhead.

(3) *Green sturgeon.* Ocean harvest for green sturgeon occurs primarily along the Oregon and Washington coasts and within their coastal estuaries. A commercial fishery for sturgeon still exists within the Columbia River, where they are caught in gill nets along with the more commercially valuable white sturgeon. Green sturgeon are also caught by recreational fisherman, and it is the primary bottomfish landed in Willapa Bay. Within the San Francisco Bay estuary, green sturgeon are captured by sport fisherman targeting the more desirable white sturgeon, particularly in San Pablo and Suisun Bays (Emmett *et al.* 1991).

b. *Freshwater Sport Harvest*

(1) *Chinook salmon.* Historically in California, almost half of the river sportfishing effort was in the Sacramento-San Joaquin River system, particularly upstream from the city of Sacramento (Emmett *et al.* 1991). Since 1987, the Fish and Game Commission has adopted increasingly stringent regulations to reduce and virtually eliminate the in-river sport fishery for winter-run Chinook salmon. Present regulations include a year-round closure to Chinook salmon fishing between Keswick Dam and the Deschutes Road Bridge and a rolling closure to Chinook salmon fishing on the Sacramento River between the Deschutes River Bridge and the Carquinez Bridge. The rolling closure spans the months that migrating adult winter-run Chinook salmon are ascending the Sacramento River to their spawning grounds. These closures have virtually eliminated impacts on winter-run Chinook salmon caused by recreational angling in freshwater.

In 1992, the California Fish and Game Commission adopted gear restrictions (all hooks must be barbless and a maximum of 5.7 cm in length) to minimize hooking injury and mortality of winter-run Chinook salmon caused by trout anglers. That same year, the Commission also adopted regulations which prohibited any salmon from being removed from the water to further reduce the potential for injury and mortality.

In-river recreational fisheries historically have taken spring-run Chinook salmon throughout the species' range. During the summer, holding adult spring-run Chinook salmon are easily targeted by anglers when they congregate in large pools. Poaching also occurs at fish ladders, and other areas where adults congregate; however, the significance of poaching on the adult population is unknown. Specific regulations for the protection of spring-run Chinook salmon in Mill, Deer, Butte, and Big Chico creeks were added to the existing CDFG regulations in 1994. The current regulations, including those developed for winter-run Chinook salmon, provide some level of protection for spring-run fish (CDFG 1998).

(2) ***Steelhead***. There is little information on steelhead harvest rates in California. Hallock *et al.* (1961) estimated that harvest rates for Sacramento River steelhead from the 1953-1954 through 1958-1959 seasons ranged from 25.1 percent to 45.6 percent assuming a 20 percent non-return rate of tags. Staley (1975) estimated the harvest rate in the American River during the 1971-1972 and 1973-1974 seasons to be 27 percent. The average annual harvest rate of adult steelhead above RBDD for the 3-year period from 1991-1992 through 1993-1994 was 16 percent (McEwan and Jackson 1996). Since 1998, all hatchery steelhead have been marked with an adipose fin clip allowing anglers to distinguish hatchery and wild steelhead. Current regulations restrict anglers from keeping unmarked steelhead in Central Valley streams (CDFG 2004c). Overall, this regulation has greatly increased protection of naturally produced adult steelhead.

(3) ***Green sturgeon.*** Green sturgeon are caught incidentally by sport fisherman targeting the more highly desired white sturgeon within the Delta waterways and the Sacramento River. Due to slot limits imposed on the sport fishery by the CDFG, only sturgeon between 46 and 72 inches may be retained by sport fisherman with a daily bag limit of 1 fish in possession. This protects both fish that are sexually immature and have not yet had an opportunity to spawn, and those larger females that have the greatest reproductive value to the population.

7. <u>Predation</u>

Accelerated predation also may be a factor in the decline of winter-run Chinook salmon and spring-run Chinook salmon, and to a lesser degree steelhead. Human-induced habitat changes such as alteration of natural flow regimes and installation of bank revetment and structures such as dams, bridges, water diversions, piers, and wharves often provide conditions that both disorient juvenile salmonids and attract predators (Stevens 1961, Decato 1978, Vogel *et al.* 1988, Garcia 1989).

On the mainstem Sacramento River, high rates of predation are known to occur at the RBDD, Anderson Cottonwood Irrigation District's diversion dam, GCID's diversion dam, areas where rock revetment has replaced natural riverbank vegetation, and at south Delta water diversion structures (*e*.g., Clifton Court Forebay; CDFG 1998). Predation at RBDD on juvenile winter-run Chinook salmon is believed to be higher than normal due to factors such as water quality and flow dynamics associated with the operation of this structure. Due to their small size, early emigrating winter-run Chinook salmon may be very susceptible to predation in Lake Red Bluff when the RBDD gates remain closed in summer and early fall (Vogel *et al.* 1988). In passing the dam, juveniles are subject to conditions which greatly disorient them, making them highly susceptible to predation by fish or birds. Sacramento pikeminnow (*Ptychocheilus grandis*) and striped bass congregate below the dam and prey on juvenile salmon in the tail waters.

FWS found that more predatory fish were found at rock revetment bank protection sites between Chico Landing and Red Bluff than at sites with naturally eroding banks (Michny and Hampton 1984). From October 1976 to November 1993, CDFG conducted 10 mark/recapture studies at the SWP's Clifton Court Forebay to estimate pre-screen losses using hatchery-reared juvenile Chinook salmon. Pre-screen losses ranged from 69 percent to 99 percent. Predation by striped bass is thought to be the primary cause of the loss (Gingras 1997).

Other locations in the Central Valley where predation is of concern include flood bypasses, post-release sites for salmonids salvaged at the State and Federal fish facilities, and the SMSCG. Predation on salmon by striped bass and pikeminnow at salvage release sites in the Delta and lower Sacramento River has been documented (Orsi 1967, Pickard *et al.* 1982); however, accurate predation rates at these sites are difficult to determine. CDFG conducted predation studies from 1987 to 1993 at the SMSCG to determine if the structure attracts and concentrates predators. The dominant predator species at the SMSCG was striped bass, and the remains of juvenile Chinook salmon were identified in their stomach contents (NMFS 1997).

8. Environmental Variation

Natural changes in the freshwater and marine environments play a major role in salmonid abundance. Recent evidence suggests that marine survival among salmonids fluctuates in response to 20- to 30-year cycles of climatic conditions and ocean productivity (Hare *et al.* 1999, Mantua and Hare 2002). This phenomenon has been referred to as the Pacific Decadal Oscillation. In addition, large-scale climatic regime shifts, such as the El NiZo condition, appear to change productivity levels over large expanses of the Pacific Ocean. A further confounding effect is the fluctuation between drought and wet conditions in the basins of the American west. During the first part of the 1990s, much of the Pacific Coast was subject to a series of very dry years, which reduced inflows to watersheds up and down the west coast.

A key factor affecting many West Coast stocks has been a general 30-year decline in ocean productivity. The mechanism whereby stocks are affected is not well understood, partially because the pattern of response to these changing ocean conditions has differed among stocks, presumably due to differences in their ocean timing and distribution. It is presumed that survival in the ocean is driven largely by events occurring between ocean entry and recruitment to a subadult life stage.

Salmon and steelhead are exposed to high rates of natural predation, particularly during freshwater rearing and migration stages. Predation rates on juvenile and adult green sturgeon have not been adequately studied to date. Ocean predation may also contribute to significant natural mortality, although it is not known to what extent. In general, salmonids are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the rebound of seal and sea lion populations following their protection under the Marine Mammal Protection Act of 1972 has increased the number of salmonid deaths.

Unusual drought conditions may warrant additional consideration in California. Flows in 2001 were among the lowest flow conditions on record in the Central Valley. The available water in the Sacramento watershed and San Joaquin watershed was 70 percent and 66 percent of normal, according to the Sacramento River Index and the San Joaquin River Index, respectively. Back-to-back drought years could be catastrophic to small populations of listed salmonids that are dependent upon reservoir releases for their success (*e.g*., Sacramento River winter-run Chinook salmon). Therefore, reservoir carryover storage (usually referred to as end-of-September storage) is a key element in providing adequate reserves to protect salmon and steelhead during extended drought periods. In order to buffer the effect of drought conditions and over allocation of resources, NMFS in the past has recommended that minimum carryover storage be maintained in Shasta and other reservoirs to help alleviate critical flow and temperature conditions in the fall. Green sturgeon's need for appropriate water temperatures would also benefit from river operations that maintain a suitable temperature profile for this species.

The future effects of global warming are of key interest to salmonid and green sturgeon survival. It is predicted that Sierra snow packs will dwindle with global warming and that the majority of runoff in California will be from rainfall in the winter rather than from melting snow pack in the mountains. This will alter river runoff patterns and transform the tributaries that feed the Central Valley from a spring/summer snowmelt dominated system to a winter rain dominated system. It can be rationally hypothesized that summer temperatures and flow levels will become unsuitable for salmonid survival. The cold snowmelt that furnishes the late spring and early summer runoff will be replaced by warmer precipitation runoff. This should truncate the period of time that suitable cold-water conditions exist below existing reservoirs and dams due to the warmer inflow temperatures to the reservoir from rain runoff. Without the necessary cold-water pool developed from melting snow pack filling reservoirs in the spring and early summer, late summer and fall temperatures below reservoirs, such as Lake Shasta, could potentially rise above thermal tolerances for juvenile and adult salmonids (*i.e.,* Sacramento River winter-run Chinook salmon and Central Valley steelhead) that must hold below the dam over the summer and fall periods. Similar, although potentially to a lesser degree, declines in green sturgeon populations are anticipated with reduced cold-water flows. Green sturgeon egg and larval development are optimized at water temperatures that are only slightly higher than those for salmonids. Lethal temperatures are similar to salmonids, although slightly higher than those for salmonids.

9. Ecosystem Restoration

a. *California Bay-Delta Authority*

Two programs included under CALFED; the Ecosystem Restoration Program (ERP) and the EWA, were created to improve conditions for fish, including listed salmonids, in the Central Valley. Restoration actions implemented by the ERP include the installation of fish screens, modification of barriers to improve fish passage, habitat acquisition, and instream habitat restoration. The majority of these actions address key factors affecting listed salmonids and emphasis has been placed in tributary drainages with high potential for steelhead and spring-run Chinook salmon production. Additional ongoing actions include new efforts to enhance fisheries monitoring and directly support salmonid production through hatchery releases. Recent habitat restoration initiatives sponsored and funded primarily by the CALFED-ERP Program have resulted in plans to restore ecological function to 9,543 acres of shallow-water tidal and marsh habitats within the Delta. Restoration of these areas primarily involves flooding lands previously used for agriculture, thereby creating additional rearing habitat for juvenile salmonids. Similar habitat restoration is imminent adjacent to Suisun Marsh (*i.e.*, at the confluence of Montezuma Slough and the Sacramento River) as part of the Montezuma Wetlands project, which is intended to provide for commercial disposal of material dredged from San Francisco Bay in conjunction with tidal wetland restoration.

A sub-program of the ERP called the Environmental Water Program (EWP) has been established to support ERP projects through enhancement of instream flows that are biologically and ecologically significant. This program is in the development stage and the benefits to listed salmonids are not yet clear. Clear Creek is one of five watersheds in the Central Valley that has been targeted for action during Phase I of the EWP.

The EWA is designed to provide water at critical times to meet ESA requirements and incidental take limits without water supply impacts to other users. In early 2001, the EWA released 290 thousand acre feet of water from San Luis Reservoir at key times to offset reductions in south Delta pumping implemented to protect winter-run Chinook salmon, delta smelt, and splittail. However, the benefit derived by this action to winter-run Chinook salmon in terms of number of fish saved was very small. The anticipated benefits to other Delta fisheries from the use of the EWA water are much higher than those benefits ascribed to listed salmonids by the EWA release.

b. *Central Valley Project Improvement Act*

The CVPIA, implemented in 1992, requires that fish and wildlife get equal consideration with other demands for water allocations derived from the CVP. From this act arose several programs that have benefited listed salmonids: the Anadromous Fish Restoration Program (AFRP), the Anadromous Fish Screen Program (AFSP), and the Water Acquisition Program (WAP). The AFRP is engaged in monitoring, education, and restoration projects geared toward recovery of all anadromous fish species residing in the Central Valley. Restoration projects funded through the AFRP include fish passage, fish screening, riparian easement and land acquisition, development of watershed planning groups, instream and riparian habitat improvement, and gravel replenishment. The AFSP combines Federal funding with State and private funds to prioritize and construct fish screens on major water diversions mainly in the upper Sacramento River. The goal of the WAP is to acquire water supplies to meet the habitat restoration and enhancement goals of the CVPIA and to improve the DOI’s ability to meet regulatory water quality requirements. Water has been used successfully to improve fish habitat for spring-run Chinook salmon and steelhead by maintaining or increasing instream flows in Butte and Mill Creeks and the San Joaquin River at critical times.

c. *Iron Mountain Mine Remediation*

EPA's Iron Mountain Mine remediation involves the removal of toxic metals in acidic mine drainage from the Spring Creek Watershed with a state-of-the-art lime neutralization plant.

Contaminant loading into the Sacramento River from Iron Mountain Mine has shown measurable reductions since the early 1990s (see Appendix J, Reclamation 2004). Decreasing the heavy metal contaminants that enter the Sacramento River should increase the survival of salmonid eggs and juveniles. However, during periods of heavy rainfall upstream of the Iron Mountain Mine, Reclamation substantially increases Sacramento River flows in order to dilute heavy metal contaminants being spilled from the Spring Creek debris dam. This rapid change in flows can cause juvenile salmonids to become stranded or isolated in side channels below Keswick Dam.

d. *State Water Project Delta Pumping Plant Fish Protection Agreement (Four-Pumps Agreement)*

The Four-Pumps Agreement Program has approved about $49 million for projects that benefit salmon and steelhead production in the Sacramento-San Joaquin basins and Delta since the agreement inception in 1986. Four-Pumps projects that benefit spring-run Chinook salmon and steelhead include water exchange programs on Mill and Deer Creeks; enhanced law enforcement efforts from San Francisco Bay upstream to the Sacramento and San Joaquin Rivers and their tributaries; design and construction of fish screens and ladders on Butte Creek; and, screening of diversions in Suisun Marsh and San Joaquin tributaries. Predator habitat isolation and removal, and spawning habitat enhancement projects on the San Joaquin tributaries benefit steelhead (see Chapter 15, Reclamation 2004).

The Spring-run Salmon Increased Protection Project provides overtime wages for CDFG wardens to focus on reducing illegal take and illegal water diversions on upper Sacramento River tributaries and adult holding areas, where the fish are vulnerable to poaching. This project covers Mill, Deer, Antelope, Butte, Big Chico, Cottonwood, and Battle Creeks, and has been in effect since 1996. Through the Delta-Bay Enhanced Enforcement Program, initiated in 1994, a team of 10 wardens focus their enforcement efforts on salmon, steelhead, and other species of concern from the San Francisco Bay Estuary upstream into the Sacramento and San Joaquin River basins. These two enhanced enforcement programs have had significant, but unquantified benefits to spring-run Chinook salmon attributed to CDFG (see Chapter 15, Reclamation 2004).

The Mill and Deer Creek Water Exchange projects are designed to provide new wells that enable diverters to bank groundwater in place of stream flow, thus leaving water in the stream during critical migration periods. On Mill Creek several agreements between Los Molinos Mutual Water Company (LMMWC), Orange Cove Irrigation District (OCID), CDFG, and DWR allows DWR to pump groundwater from two wells into the LMMWC canals to pay back LMMWC water rights for surface water released downstream for fish. Although the Mill Creek Water Exchange project was initiated in 1990 and the agreement allows for a well capacity of 25 cubic feet per second (cfs), only 12 cfs has been developed to date (Reclamation and OCID 1999). In addition, it has been determined that a base flow of greater than 25 cfs is needed during the April through June period for upstream passage of adult spring-run Chinook salmon in Mill Creek (Reclamation and OCID 1999). In some years, water diversions from the creek are curtailed by amounts sufficient to provide for passage of upstream migrating adult spring-run Chinook salmon and downstream migrating juvenile steelhead and spring-run Chinook salmon. However, the current arrangement does not ensure adequate flow conditions will be maintained in all years. DWR, CDFG, and FWS have developed the Mill Creek Adaptive Management Enhancement

Plan to address the instream flow issues. A pilot project using 1 of the 10 pumps originally proposed for Deer Creek was tested in summer 2003. Future testing is planned with implementation to follow.

10. Non-native Invasive Species

As currently seen in the San Francisco estuary, non-native invasive species (NIS) can alter the natural food webs that existed prior to their introduction. Perhaps the most significant example is illustrated by the Asiatic freshwater clams *Corbicula fluminea* and *Potamocorbula amurensis*. The arrival of these clams in the estuary disrupted the normal benthic community structure and depressed phytoplankton levels in the estuary due to the highly efficient filter feeding of the introduced clams (Cohen and Moyle 2004). The decline in the levels of phytoplankton reduces the population levels of zooplankton that feed upon them, and hence reduces the forage base available to salmonids transiting the Delta and San Francisco estuary which feed either upon the zooplankton directly or their mature forms. This lack of forage base can adversely impact the health and physiological condition of these salmonids as they emigrate through the Delta region to the Pacific Ocean.

Attempts to control the NIS also can adversely impact the health and well-being of salmonids within the affected water systems. For example, the control programs for the invasive water hyacinth and *Egeria densa* plants in the Delta must balance the toxicity of the herbicides applied to control the plants to the probability of exposure to listed salmonids during herbicide application. In addition, the control of the nuisance plants has certain physical parameters that must be accounted for in the treatment protocols, particularly the decrease in DO resulting from the decomposing vegetable matter left by plants that have died.

11. Summary

Land-use activities such as road construction, urban development, logging, mining, agriculture, and recreation are pervasive and have significantly altered fish habitat quantity and quality for Chinook salmon and steelhead through alteration of streambank and channel morphology; alteration of ambient water temperatures; degradation of water quality; elimination of spawning and rearing habitat; fragmentation of available habitats; elimination of downstream recruitment of LWD; and, removal of riparian vegetation resulting in increased streambank erosion. Human-induced habitat changes, such as: alteration of natural flow regimes; installation of bank revetment; and, building structures such as dams, bridges, water diversions, piers, and wharves, often provide conditions that both disorient juvenile salmonids and attract predators. Harvest activities, ocean productivity, and drought conditions provide added stressors to listed salmonid populations. In contrast, various ecosystem restoration activities have contributed to improved conditions for listed salmonids (*e.g.*, various fish screens). However, some important restoration activities (*e.g.*, Battle Creek) have not yet been initiated. Benefits to listed salmonids from the EWA have been smaller than anticipated.

D. Critical Habitat Condition and Function for Species' Conservation

The freshwater habitat of salmon, steelhead, and sturgeon in the Sacramento River, San Joaquin River, and Suisun Marsh watershed drainages varies in function depending on location. Spawning areas are located in accessible, upstream reaches of the Sacramento or San Joaquin Rivers and their watersheds where viable spawning gravels and water quality are found. Spawning habitat condition is strongly affected by water flow and quality, especially the primary constituent elements (PCEs) of temperature, DO, and silt load, all of which can greatly affect the survival of eggs and larvae. High quality spawning habitat is now inaccessible behind large dams in these watersheds, which limits salmonids to spawning in marginal tailwater habitat below the dams. Despite often intensive management efforts, the existing spawning habitat below dams is highly susceptible to inadequate flows and high temperatures due to competing demands for water, which impairs the habitat function.

Migratory corridors are downstream of the spawning area and include the Delta and Suisun Marsh. These corridors allow the upstream passage of adults and the downstream emigration of juveniles. Migratory habitat conditions are impaired in each of these drainages by the presence of barriers, which can include seasonal dams, unscreened or poorly-screened diversions, inadequate water flows, and degraded water quality.

Both spawning areas and migratory corridors comprise rearing habitat for juveniles, which feed and grow before and during their outmigration. Non-natal, intermittent tributaries also may be used for juvenile rearing by salmonids, but such use has not been documented for sturgeon. Rearing habitat condition is strongly affected by PCEs such as habitat complexity, food supply, and presence of predators of juvenile salmonids and sturgeon. Some complex, productive habitats with floodplains remain in the Sacramento and San Joaquin River systems (*e.g.*, the lower Cosumnes River, Sacramento River reaches with setback levees (*i.e.*, primarily located upstream of the City of Colusa) and the Yolo and Sutter bypasses). However, the channelized, leveed, and riprapped river reaches and sloughs that are common in the Delta and Suisun Marsh systems typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators.

IV. ENVIRONMENTAL BASELINE

A. Factors Affecting the Species and Habitat in the Action Area

Starting in the mid-1800s, the U.S. Army Corps of Engineers (Corps) and other private consortiums began straightening river channels and artificially deepening them to enhance shipping commerce. This has led to declines in the natural meandering of river channels and the formation of pool and riffle segments. The deepening of channels beyond their natural depth also has led to a significant alteration in the transport of bedload in the riverine system as well as the local flow velocity in the channel (Mount 1995). The Sacramento Flood Control Project at the turn of the nineteenth century ushered in the start of large scale Corps actions in the Delta and along the rivers of California for reclamation and flood control. The creation of levees and the Sacramento and San Joaquin deep water ship channels (DWSCs) reduced the natural tendency of the San Joaquin and Sacramento Rivers to create floodplains along their banks with seasonal inundations during the wet winter season and the spring snow melt periods. These annual inundations provided necessary habitat for rearing and foraging of juvenile native fish that evolved with this flooding process. The armored riprapped levee banks and active maintenance actions of reclamation districts precluded the establishment of ecologically important riparian vegetation, introduction of valuable LWD from these riparian corridors, and the productive intertidal mudflats characteristic of the undisturbed Delta habitat.

Low DO levels frequently are observed in the portion of the DWSC extending from Channel Point, downstream to Turner and Columbia Cuts. Over a 5-year period, starting in August 2000, a DO meter has recorded channel DO levels at Rough and Ready Island (Dock 20 of the Port of Stockton, West Complex). Over the course of this time period, there have been 297 days in which violations of the 5 mg/l DO criteria for the protection of aquatic life in the San Joaquin River between Channel Point and Turner and Columbia Cuts have occurred during the September through May migratory period for salmonids in the San Joaquin River. The data derived from the California Data Exchange Center files indicate that DO depressions occur during all migratory months, with significant events occurring from November through March when listed Central Valley steelhead adults and smolts would be utilizing this portion of the San Joaquin River as a migratory corridor (see Appendix A, Table 6).

Potential factors that contribute to these DO depressions are reduced river flows through the ship channel, released ammonia from the City of Stockton Wastewater Treatment Plant, upstream contributions of organic materials (*e.g.*, algal loads, nutrients, agricultural discharges) and the increased volume of the dredged ship channel. During the winter and early spring emigration period, increased ammonia concentrations in the discharges from the City of Stockton Waste Water Treatment Facility lowers the DO in the adjacent DWSC near the West Complex. In addition to the adverse effects of the lowered DO on salmonid physiology, ammonia is in itself toxic to salmonids at low concentrations. Likewise, adult fish migrating upstream will encounter lowered DO in the DWSC as they move upstream in the fall and early winter due to low flows and excessive algal and nutrient loads coming downstream from the upper San Joaquin River watershed. Levels of DO below 5 mg/L have been reported as delaying or blocking fall-run Chinook salmon in studies conducted by Hallock *et al.* (1970). As the river water and its constituents move downstream from the San Joaquin River channel to the DWSC, the channel depth increases from approximately 8 to 10 feet to over 35 feet. The water column is no longer mixed adequately to prevent DO from decreasing as it is consumed by biotic and abiotic factors. This is due to the increased amount of time the water spends away from the air-water interface where equilibration with atmospheric oxygen can occur. Photosynthesis by suspended algae is diminished by increased turbidity and circulation below the photosynthetic compensation depth. This is the depth to which light penetrates with adequate intensity to carry on photosynthesis in excess of the oxygen demands of cellular respiration. As the oxygen demand from respiration, defined as biological oxygen demand, exceeds the rate at which oxygen can be produced by photosynthesis and mixing, then the level of DO in the water column will decrease. Additional demands on oxygen are also exerted in non-biological chemical reactions in which compounds consume oxygen in an oxidation-reduction reaction.

NMFS completed consultation on the Port of Stockton (Port), West Complex Dredging project on July 19, 2005 (NMFS Project No. 151422SWR2003SA9009;9010JSS; NMFS 2005b). The Port is situated on the San Joaquin River between RM 37.5 and RM 41. The proposed Port of

Stockton, West Complex Dredging project will involve dredging approximately 576,000 cy of material from the waters of the San Joaquin River, adjacent to the Port's wharves at the West Complex. Disposal of this material will occur at the dredge material placement (DMP) site on Roberts Island, which also will be used to facilitate dredge material disposal associated with the project that is the focus of the present consultation. The dredging activities are anticipated to exacerbate the low DO conditions in the DWSC. However, the Port of Stockton, West Complex Dredging project is a part of a much larger action, called the West Complex Redevelopment project as described in the Port's draft EIR for the project (Environmental Science Associates 2003). Interrelated and interdependent activities include upland development of the former naval facilities on Rough and Ready Island with the intent of accommodating larger ships compared to those that currently use the DWSC. This development will result in an approximate doubling of ship traffic in the San Joaquin River. Hence, these activities will affect that portion of the action area for the current project that encompasses the waters adjacent to the Stockton DWSC.

In addition to the adverse effects of dredging and release of effluent from the DMP site, the Port of Stockton, West Complex Dredging project is expected to adversely affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead transiting the action area through increased shipping impacts including, but not limited to, propeller entrainment and changes in channel hydrodynamics (*e.g.*, creation of shear forces and turbulent mixing created by vessel passage).

The total incidental take associated with the Port of Stockton, West Complex Dredging project was estimated by NMFS as follows:

Species	Number Juveniles	Percentage of ESU/DPS	Number Adults	Percentage of ESU/DPS
Sacramento River winter-run Chinook salmon	2,500	0.80	0	0
Central Valley spring-run Chinook salmon	5000	0.32	0	0
Central Valley Steelhead	280	0.15	3	0.15

NMFS's biological opinion on the Port of Stockton, West Complex Dredging project (NMFS 2005b) did not assess the project's effects on the southern DPS of North American green sturgeon. However, NMFS (2005b) states the following:

> Recent discussions with CDFG staff have indicated that adult sturgeon have been recovered with obvious propeller scars, some resulting in death, during fish monitoring surveys (Gingras 2005). These incidents occurred immediately following the passage of large ocean going ships in the San Joaquin River channel.

The expected increase in shipping notwithstanding, this statement suggests that the ongoing impact of shipping at present levels likely is adversely affecting listed and proposed species.

B. Presence of Listed Salmonids in the Action Area

The action area for the WHCP includes the entire legal Delta as well as the eastside tributaries feeding the Delta and the San Joaquin River upstream to Friant Dam. All of the listed Central Valley steelhead in the San Joaquin River watershed originating from the Calaveras, Stanislaus, Tuolumne, or Merced Rivers must pass through the Delta on both their downstream emigration to the ocean as smolts and on their upstream spawning migrations as adults. Those few adults that survive to spawn a second time would also pass through this portion of the action area again. Those fish with origins in the Sacramento River watershed must pass through the northern treatment areas of the WHCP in the north Delta on the way to the ocean.

Based on fish monitoring studies, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead juveniles and smolts from the Sacramento River watershed frequently enter into the San Joaquin River system based on river flows and SWP and CVP pumping rates. Fish from the Sacramento River can access the San Joaquin River from several points, the Delta Cross Channel via the North and South Forks of the Mokelumne River, Georgiana Slough, Three Mile Slough, and the mouth of the San Joaquin River near Antioch and Sherman Island.

C. Presence of North American Green Sturgeon in the Action Area

Both adult and juvenile North American green sturgeon are known to occur within the lower reaches of the San Joaquin River, the south Delta, the waterways of the north Delta and Sacramento River itself within the action area. Juveniles have been captured in the vicinity of Santa Clara Shoals and Brannan Island State Recreation Area, and in the channels of the south Delta (Moyle *et al.* 1992, Beamesderfer *et al.* 2004). Green sturgeon also have been recovered at both the SWP and CVP pumping facilities on Old River near Tracy, indicating that they must have transited through one of the many channels of the south Delta to reach that location. Both adult and juvenile green sturgeon may use the Delta as a migratory, resting, or rearing habitat. Green sturgeon presence in the Delta could occur in any month, as juveniles may reside there during their first few years of growth. Adults are likely to be present in the winter and early spring as they move through the Delta towards their spawning grounds in the upper Sacramento River watershed. Following spawning, the fish will pass through the Delta again on their way back to the ocean, but the duration and timing of this event is not well understood in the Sacramento River system.

V. EFFECTS OF THE ACTION

Pursuant to section 7(a)(2) of the ESA (16 U.S.C. §1536), Federal agencies are directed to ensure that their activities are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. This biological and conference opinion assesses the effects of the USDA-ARS' WHCP on endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, threatened Central Valley steelhead, proposed threatened southern DPS of North American green sturgeon, and their designated critical habitats. The proposed action is likely to adversely affect listed salmonids, North American green sturgeon, and their habitat primarily through the application of herbicides and adjuvants to floating water hyacinth in infested areas, changes in water quality parameters associated with the application of herbicides and the decomposition of the treated plant material, and the collateral alterations of the plant communities in response to the application of herbicides to the non-native invasive water hyacinth. In the *Description of the Proposed Action* section of this opinion, NMFS provided an overview of the action. In the *Status of the Species* and *Environmental Baseline* sections of this opinion, NMFS provided an overview of the threatened and endangered species and critical habitats that are likely to be adversely affected by the activity under consultation.

Regulations that implement section 7(a)(2) of the ESA require that biological opinions evaluate the direct and indirect effects of Federal actions and actions that are interrelated with or interdependent to the Federal action to determine if it would be reasonable to expect them to appreciably reduce listed species' likelihood of surviving and recovering in the wild by reducing their reproduction, numbers, or distribution (16 U.S.C. §1536, 50 CFR §402.02).

NMFS generally approaches "jeopardy" analyses in a series of steps. First, NMFS evaluates the available evidence to identify direct and indirect physical, chemical, and biotic effects of the proposed actions on individual members of listed species or aspects of the species' environment (these effects include direct, physical harm or injury to individual members of a species; modifications to something in the species' environment - such as reducing a species' prey base, enhancing populations of predators, altering its spawning substrate, altering its ambient temperature regimes; or adding something novel to a species' environment - such as introducing exotic competitors or a sound). Once NMFS has identified the effects of the action, the available evidence is evaluated to identify a species' probable response, including behavioral reactions, to these effects. These responses then will be assessed to determine if they can reasonably be expected to reduce a species' reproduction, numbers, or distribution (for example, by changing birth, death, immigration, or emigration rates; increasing the age at which individuals reach sexual maturity; decreasing the age at which individuals stop reproducing; among others). The available evidence is then used to determine if these reductions, if there are any, could reasonably be expected to appreciably reduce a species' likelihood of surviving and recovering in the wild.

The regulatory definition of adverse modification has been invalidated by the courts. Until a new definition is adopted, NMFS will evaluate destruction or adverse modification of critical habitat by determining if the action reduces the value of critical habitat for the conservation of the species.

A. Approach to Assessment

1. <u>Information Available for the Assessment</u>

To conduct the assessment, NMFS examined an extensive amount of evidence from a variety of sources. Detailed background information on the status of these species and critical habitat has been published in a number of documents including peer reviewed scientific journals, primary reference materials, governmental and non-governmental reports, scientific meetings, and environmental reports submitted by the project proponents. Additional information investigating the effects of the project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was obtained from the aforementioned resources.

2. Assumptions Underlying This Assessment

In the absence of definitive data or conclusive evidence, NMFS must make a logical series of assumptions to overcome the limits of the available information. These assumptions will be made using sound, scientific reasoning that can be logically derived from the available information. The progression of the reasoning will be stated for each assumption, and supporting evidence cited.

Exposure potential and risk assessment of listed species to herbicides is predicated on having a detailed understanding of the multiple avenues of physiological and behavioral interactions associated with the exposure in the natural environment. Although there is considerable information available concerning the herbicide concentrations required for acute mortality in fish and other aquatic organisms in controlled laboratory settings, specific data concerning listed salmonids and green sturgeon is lacking in most instances, and particularly so for natural systems. Furthermore, studies that are designed to investigate the sublethal effects of herbicide exposure are still rare, and even rarer are studies looking at the effects of herbicide exposure in complicated natural systems, with multiple stressors and contaminants present. In order to account for these unknowns, NMFS must apply the precautionary principle and err on the side of the species when assessing impacts of the project's actions.

B. Assessment

1. Natural History of Water Hyacinth

Water hyacinth is a non-native invasive free-floating aquatic macrophyte belonging to the South American pickerelweed family (*Pontederiacea*). It is considered to be one of the most invasive species worldwide, having been reported in 56 countries worldwide (Holm *et al.* 1977, Gopal and Sharma 1981).

Water hyacinth was first reported in California in a Yolo County slough in 1904 (Prokopovich *et al.* 1985). The plant gradually spread through the Delta and by the late 1970s had covered nearly 1,000 acres and 150 miles of the 700 miles of waterways in the Delta (U.S. Army Corps of Engineers 1985). The spread of water hyacinth in the Delta was probably inhibited by the cool winters and occasional freezes that occur in the Central Valley, which can kill or severely retard growth of the water hyacinth (Holm *et al.* 1977).

Water hyacinth grows in wetlands, marshes, shallow water bodies, slow moving waterways, lakes, reservoirs, and rivers. The plants often form large, thick mats that are monospecific in nature. Mats can reach dimensions that can block waterways and impede navigation, agricultural practices, and pursuit of recreational activities. Dense mats can also serve as breeding grounds for mosquitoes, which can increase the possibility of vector born diseases in surrounding areas (Savage *et al.* 1990, Meyers 1992, Rodriguez *et al.* 1993, and Manguin *et al.* 1996). During high wind or river flow conditions, small floats of water hyacinth often break off from the larger mats and colonize new areas. Water hyacinths are tolerant of fluctuations in water levels, seasonal flow velocities, and extremes of nutrient availability, pH, toxicants, and temperatures. However, the plants are susceptible to even low levels of salinity, and perish in these environments.

The water hyacinth growth cycle starts in spring when over-wintering plants (old stem bases) initiate new growth by producing daughter plants. The minimum growth temperature is 54 ^{o}F, optimal growth temperatures are reached at 77-86 ^{o}F and maximum growth temperature is reached at 92-95 ^{o}F. The daughter plants increase in number during spring and summer until the maximum biomass is reached in September. When the density of the mats has reached its maximum, individual plants begin to increase in size, crowding out smaller plants. This decreases the overall number of plants in the mats, while still maintaining high biomass. Water hyacinth grows faster than any other tested plant (Wolverton and McDonald 1979) and can double its numbers in as little as 6 days (Mitchell 1976). During late summer and early fall, the plants reach their full bloom. By late fall, the flowers and leaves begin to die back, and by January most of the plants have gone dormant. Water hyacinths are not very tolerant to freezing conditions, and cold climates limit their northern range. Leaves can regrow after moderate freezing, but plants do not survive hard freezes or ice conditions.

2. Problems Associated with Water Hyacinth Infestation

Typically, aquatic vegetation plays an important, beneficial role in the functioning of an aquatic ecosystem. Aquatic vegetation produces oxygen through photosynthesis that leads to an elevation of ambient DO levels in the water column. Macrophytes provide shelter and habitat for invertebrates and juvenile fish whether they are rooted in the substrate or are free floating. Macrophytes also provide substrate for periphyton (algae, fungus, and microflora) to grow on which in turn provides food resources for grazing invertebrates. These invertebrates then provide the basis for the food resources of higher trophic levels, such as fish. Aquatic plants also enhance the cycling of nutrients and minerals in the aquatic ecosystems of which they are part. This is done by incorporating them into the plant tissue, which then serves as a nutritional substrate for herbivores or as a nutrient source for bacteria and fungi during their decay. Native aquatic plants are co-evolved with the other flora and fauna in their ecosystems and thus are in equilibrium with the other components of the ecosystem.

Non-native invasive species are those plants or organisms which have been introduced into an ecosystem in which they have not evolved. These species do not have the checks and balances on their numbers and range that native species have and are likely to adversely affect native species in the invaded ecosystem. Water hyacinth is such a species. The infestation of the Delta with water hyacinth has resulted in several negative impacts on this ecosystem. The increased biomass of water hyacinth has resulted in nighttime depletion of DO through increased levels of plant respiration, particularly during periods of elevated water temperatures. The extensive coverage of water hyacinth mats have excluded numerous species of submerged native plants by shading-out these plants or smothering emergent plants that become surrounded by the mats. Likewise, the extensive mats have created zones of hypoxic or anoxic water conditions due to extensive plant respiration and lack of water-air interface mixing. These conditions have altered the normal assemblages of invertebrate and vertebrate species normally found in ecosystems without the water hyacinth (Baily and Litterick 1993, Toft 2000, CALFED 2000). Water hyacinths can also lead to abiotic changes in the ecosystem such as accretion of sediment and organic detritus under the mats due to reductions of water flows through the infested sites. Likewise, the ability of the water hyacinth to absorb vast amounts of nutrients and minerals through its extensive root structure can lead to the formation of nutrient sinks in the infested zones. These sinks essentially remove these nutrients from the ecosystem due to the inability of native organisms to feed on the water hyacinth, or survive in the conditions created by the water hyacinth.

3. Physio-chemical Properties of Program Herbicides and Adjuvants

The mode-of-action is the overall manner in which an herbicide affects a plant at the tissue or cellular level. Herbicides can be organized into those which are applied to foliage, and those which are applied almost strictly to soil. The foliar groups are further divided into three categories according to movement through the plant:

- Symplastically translocated (source to sink, capable of downward movement in plant),
- Apoplastcially translocated (capable of upward movement in plant), and
- Those which do not move appreciably and kill very quickly on contact.

Plants are complex organisms with well-defined structures and numerous biochemical processes that are necessary for life. Some of these vital metabolic pathways include photosynthesis, amino acid and protein synthesis, fat synthesis, pigment synthesis, nucleic acid synthesis, oxidative respiration for energy, and maintenance of cellular membrane integrity. Other essential processes include growth and differentiation, mitosis (cell division) in plant meristems, meiosis (sexual gamete production- pollen and seeds), uptake of ions and molecules, translocation of ions and compounds across cellular membranes, and transpiration. One or more of these essential processes must be disrupted in order for an herbicide to kill a plant (Ross and Childs 1996).

Foliar applied herbicides are either downwardly mobile, contact (non-translocated), or upwardly mobile in their mode-of–action. Downwardly mobile herbicides can be further divided into auxin growth regulators (2,4-D), aromatic amino acid synthesis inhibitors (glyphosate), branched chain amino acid inhibitors, chlorophyll/carotenoid pigment inhibitors, or lipid synthesis inhibitors (meristem membranes). Contact herbicides destroy by disrupting the cellular membranes of plants. Diquat belongs to this class of herbicides and functions by producing peroxides and free radicals in the cytoplasm upon exposure to light, which then destroy the lipid membranes of the cells almost immediately. Upwardly mobile herbicides move with the transpiration stream in the plant's xylem from the bottom to the top of the plant. This group of herbicides inhibits the photosynthetic pathways of metabolism. Soil applied herbicides inhibit cellular division in the roots, new shoots or both (Ross and Childs 1996).

Weedar ® 64, a dimethylamine salt formulation of 2,4-Dichlorophenoxyacetic acid (46.8 percent active ingredient) is an auxin growth regulator. This type of herbicide is applied to the foliage of plants, which almost immediately results in a bending and twisting of the leaves and stems. Delayed symptoms include root formation on dicot stems, misshapened leaves, stems, and flowers and abnormal roots. The amine salt form has been shown to be less toxic to fish than the ester forms of the herbicide, while invertebrates show a higher sensitivity to both the ester and amine forms of the compound than fish. The half-life of Weedar ® in aquatic environments can be short, from several days to several weeks (Extoxnet 2001). Rates of breakdown increase with increased levels of nutrients, sediments, and dissolved organic carbon. Maximum concentrations in surface waters are reached in one day, and then dissipate rapidly, especially in moving water (USDA 2002). Microorganisms readily breakdown 2,4-D along two separate metabolic pathways, metabolizing the compound into either pyruvate or 3-oxo-adipate. These intermediate metabolites serve as precursors to other metabolic pathways in the degrading microorganisms (Hill *et al.* 2002). The manufacturer's Material Safety Data Sheet (MSDS, Rhône-Poulenc) indicates that this product is "for use in ponds, lakes, reservoirs, marshes, bayous, drainage ditches, canals, rivers, and streams that are quiescent or slow moving." It further stipulates that "to avoid fish kills from the decaying plant material consuming oxygen, buffer strips of at least 100 feet wide should be left, and that treatment of these strips should be delayed for 4 to 5 weeks or until the dead vegetation has decomposed". This will be the primary compound used for water hyacinth control by the DBW, accounting for more than 75 percent of chemical usage in the last three years. Concentrations of 2,4-D in the receiving waters shall not exceed 20 µg/L following application.

Rodeo®, an isopropylamine salt formulation of glyphosate (53.8 percent active ingredients) is a non-selective, slow acting systemic herbicide that inhibits aromatic amino acid synthesis. This type of herbicide is sprayed on the foliage due to its rapid degradation by microbes. Symptoms include yellowing of new growth and death of treated plants in days to weeks (Ross and Childs 1996). Glyphosate inhibits an essential enzyme pathway, the shikimic acid pathway. This inhibition prevents plants from synthesizing three key aromatic amino acids, phenylalanine, tyrosine, and tryptophan. These enzymes are essential for the normal growth and survival of most plants. Plants are inefficient at metabolizing glyphosate; therefore, the compound readily disseminates throughout the target plant and provides a more effective herbicide (Hartzler 2001). Animals do not synthesize either phenylalanine or tryptophan, and thus require them in their diets to survive (essential amino acids). Glyphosate rapidly degrades in aquatic systems either by photodegradation (. 28 days) or by microbial degradation into sarcosine or formaldehyde, which then enters the intermediate single carbon metabolism of the bacteria. Glyphosate is also strongly adsorbed to soil particles and suspended particulate matter in the water column, rendering it "biologically unavailable" to most aquatic organisms. Toxicological data indicates that the parent compound, glyphosate, is relatively benign to fish at expected acute field concentrations. Increased toxicity has been shown to occur when the parent compound is mixed with spray adjuvants and the inert portions of the manufacturer's formulation. The manufacture's MSDS (Monsanto) states that the product may be "applied to emergent weeds in all bodies of fresh and brackish water which may include flowing, non-flowing, and transient waters." Rodeo® does not effectively treat plants which are completely submerged or have the majority of their foliage under water. Restrictions also apply to the application of Rodeo® near potable water intakes. As with 2,4-D, hypoxic conditions may be formed in the water column due to excessive weed decay from previous treatments, thereby causing fish to suffocate from a lack of DO. It is recommended that treating the area in strips may avoid this problem. This will be the least used compound for water hyacinth control by the DBW. Concentrations of glyphosate in the receiving waters shall not exceed 700 µg/L following application.

Reward®, which contains 36.4 percent diquat dibromide as an active ingredient, is a "broad spectrum" contact herbicide that destroys lipid membranes and disrupts photosynthetic organelles. Diquat is readily absorbed through the plant cuticle and passes into the cytosol of the plant. It then forms superoxide free radicals that are subsequently converted into hydrogen peroxides by the enzyme superoxide dismutase. The hydrogen peroxide and superoxide anion can attack polyunsaturated lipids present in the cellular membranes to produce lipid hydroperoxides which, in turn, can react with unsaturated lipids to form more lipid free radicals, thereby perpetuating the system (Ecobichon in Klassen 1996). Diquat rapidly adsorbs to soil particles and suspended particles in water. It thus becomes relatively biologically unavailable to most aquatic organisms. Diquat dibromide's half-life is less than 48 hours in the water column, and may be on the order of 160 days in sediments due to its low bioavailability. Microbial degradation or sunlight may play roles in the degradation of the compound. Plants can absorb diquat from the water and concentrate it in the plant's tissues. Thus, low concentrations are effective for controlling aquatic weeds. Diquat is considered slightly toxic to fish and aquatic invertebrates. It has been reported to be less toxic in hard waters. There is little or no bioconcentration of diquat in fish due to its limited absorption from the gastrointestinal tract (Extoxnet 1993, 1996). One research paper indicated that yellow perch (*Perca flavescens*) exhibited respiratory difficulties when herbicide concentrations were similar to those present during aquatic vegetation control programs (Bimber 1976). The manufacturer's MSDS for Reward® (Zeneca) indicates that the herbicide may be applied to aquatic weeds. In public waters, the herbicide may be applied to still, slow-moving, or other quiescent bodies of water and that if warning signs are required by state law they must be posted within the restricted area (1600 feet downstream of the treatment site). Due to the likelihood of hypoxic or anoxic conditions resulting from the decay of dead plant material, the MSDS requires that only one third to one half of the water body be treated at any one time, especially if dense weeds are present, and to wait 24 hours between treatments. Diquat has not been used in the WHCP for the last three seasons (2003 through 2005) although DBW has retained it in its herbicide usage protocol for the next five years as described in the BA for the current consultation (DBW 2005). Concentrations of diquat in the receiving waters shall not exceed 0.5µg/L following application as directed by the current NPDES permit for the WHCP.

4. Effects of Herbicidal Application on Salmonids

The application of herbicides to waters of the Delta and the San Joaquin River Basin under the USDA-ARS' and DBW's WHCP actions from 2006 to 2010 potentially may affect Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and the Central Valley steelhead in both direct and indirect ways.

a. *Dissolved Oxygen Levels*

Juvenile salmonids may be directly affected through the reduction in DO levels resulting from the decomposition of plants killed from the herbicide application. Low DO levels (< 3 mg/L) can result in fish kills if fish are unable to move out of the zone of hypoxic or anoxic waters. Low DO levels are particularly harmful to salmonids, which have a high metabolic requirement for DO (Bjornn and Reiser 1991). Studies have shown that DO levels below 5 mg/L have a significant negative effect on growth, food conversion efficiency, and swimming performance. High water temperatures, which result in reduced oxygen solubility, can compound the stress on fish caused by marginal DO concentrations (Bjornn and Reiser 1991). Stress from low DO can make juvenile salmonids more susceptible to predation and disease, and less likely to smolt due to insufficient energy reserves. Adult salmonids may experience delayed migration through Delta waters if DO is below concentrations needed for survival. Delay in upstream migration can have a negative impact on the maturation of gonadal tissue, particularly if ambient water temperatures in the Delta are also elevated. Salmonids exposed to elevated temperatures during gonadal maturation have reduced fertility and lower numbers of viable eggs (CALFED 2000). Previous studies have shown that levels of DO under water hyacinth mats can be hypoxic or even anoxic (Bailey and Litterick 1993, Toft 2000) having values that are less than 5 mg/L. Fish exposed to extended dissolved oxygen levels below 5 mg/L are usually compromised in their growth and survival (Piper *et al.* 1982). NMFS expects that fish and mobile invertebrates generally will avoid areas with large mats of water hyacinth due to the decreased ambient levels of DO in the water column. The applications of herbicides are expected to initially decrease DO levels even further in areas treated for the plant. This results from the decomposition of the dead vegetable matter and an increase in biological oxygen demand. This effect is expected to be transitory as the decaying vegetation is dispersed by tidal and river currents from the treatment area. Areas of higher tidal and river current exposure will be flushed faster than areas of low water body exchange, such as dead end sloughs and restricted peripheral channels. Additional parameters affecting the DO levels are the rate of decay for the treated vegetation which is dependent on ambient water temperature and microbial activity. Higher water temperatures should theoretically result in higher microbial activity, thus resulting in a faster decline in the DO levels. However, the duration of the depressed DO levels should be shorter than in a cooler temperature profile due to the vegetative biomass being metabolized at a faster rate. Conversely, a cooler ambient temperature would result in a prolonged DO depression, although perhaps not to the hypoxic levels reached in a warmer water profile.

b. *Narcosis*

Fish, which are exposed to elevated concentrations of polar and non-polar organic compounds, such as the herbicides used in the WHCP, can become narcotized. Narcosis is a generalized non-selective toxicity that is the result of a general disruption of cell membrane function. The process of narcosis is poorly understood, but is thought to involve either a “critical volume” change in cellular membranes due to the toxicant dissolving into the lipid membrane and altering its function, or by the “protein binding” process in which hydrophobic portions of receptor proteins in the lipid membrane are bound by the toxicant molecules, thus changing the receptor protein’s function (Rand 1995). Exposure to elevated concentrations of the herbicides would occur in the very upper most portions of the water column, directly beneath the fringe of the water hyacinth mat. A fish with narcosis would be susceptible to predation as a result of a loss of equilibrium, a reduction in swimming ability or a lack of predator avoidance behavior. Furthermore, a fish with narcosis would also have difficulty maintaining its position in the water column, and potentially could be carried by water currents into areas of sub-optimal water quality where conditions may be lethal to salmonids (hypoxic regions underneath water hyacinth mats).

c. *Sublethal Effects on Salmonids*

In contrast to the acute lethality endpoints utilized by the WHCP, nonlethal or sublethal endpoints are more appropriate to the levels of exposure likely to be seen in the herbicide application protocol employed in the program. Sublethal or nonlethal endpoints do not require that mortality be absent; rather it indicates that death is not the primary toxic endpoint being examined. Rand (1995) states that the most common sublethal endpoints in aquatic organisms are behavioral (*e.g*., swimming, feeding, attraction-avoidance, and predator-prey interactions), physiological (*e.g*., growth, reproduction, and development), biochemical (*e.g*., blood enzyme and ion levels), and histological changes. Some sublethal effects may indirectly result in mortality. Changes in certain behaviors, such as swimming or olfactory responses, may diminish the ability of the salmonids to find food or escape from predators and may ultimately result in death. Some sublethal effects may have little or no long-term consequences to the fish because they are rapidly reversible or diminish and cease with time. Individual fish of the same species may exhibit different responses to the same concentration of toxicant. The individual condition of the fish can significantly influence the outcome of the toxicant exposure. Fish with greater energy stores will be better able to survive a temporary decline in foraging ability, or have sufficient metabolic stores to swim to areas with better environmental conditions. Fish that are already stressed are more susceptible to the deleterious effects of contaminants, and may succumb to toxicant levels that are considered sublethal to a healthy fish.

Exposure of fish to the aromatic hydrocarbons typical of many families of pesticides, results in the biotransformation of these compounds by various detoxifying enzyme systems in the fish. Most organic contaminants are lipophilic, a property that makes these compounds readily absorbed across the lipid membranes of the gill, skin, and gastrointestinal tract. Following absorption, compounds that are susceptible to biotransformation are converted to more water soluble metabolites that are easier to excrete than the parent compound. Compounds that are resistant to metabolism are often sequestered in the lipid-rich tissues of the body. Although biotransformation is often considered a positive event in the detoxification of the contaminant, the parent compound of some contaminants are actually less toxic than the metabolites formed. These reactive intermediate metabolites can cause significant problems in other metabolic pathways, including alterations in the synthesis of DNA and RNA, redox cycling of reactive compounds, and induction of enzymatic systems that could lead to altered metabolism of environmentally encountered contaminants (Di Giulo *et al.* in Rand 1995). Within the Delta, mixtures of contaminants, particularly organophosphate pesticides are common. Induction of the biotransforming enzymatic pathways, particularly the P450 monooxygenases, may actually increase the sensitivity of a fish to environmental contaminants. Organophosphate insecticides are often activated by the mono-oxygenase system (Murty 1986, Dr. M.J. Lydy. Southern Illinois University, Carbondale, personal communication 2003), thus the higher the activity of the mono-oxygenase system, the higher the potential for the formation of reactive metabolites.

d. *Indirect Effects*

Indirect effects may result from temporary reductions in primary productivity and invertebrate populations in treated reaches, increased water temperatures in previously shaded habitats, and exposure to predation resulting from a loss of cover as a result of exposure to the chemical compounds used in the WHCP. Invertebrate populations may be reduced either by direct toxic exposure to herbicides in the water column or indirectly by drifting decaying vegetation smothering the benthic substrate they inhabit. Either avenue would diminish the forage base needed by juvenile salmonids utilizing the Delta as a rearing habitat or within the natal rivers of the San Joaquin Basin where fry and fingerlings are present. Juvenile salmonids would then be forced to enlarge their forage area to successfully ingest the necessary caloric intake for survival. The rate of survival for juvenile salmonids would be a balance between the amounts of metabolic energy expended in swimming during foraging behavior versus the amount of caloric intake achieved from the prey captured during foraging. Caloric intake needs to exceed the metabolic cost of swimming in order for the juvenile fish to have sufficient energy reserves for growth and other metabolic needs. An additional indirect effect is the increase in monitoring for the status of listed fish (*i.e.* delta smelt), where listed fish other than the target species are caught as bycatch in the sampling procedures. This bycatch often results in the loss of the listed salmonids. Finally, operation of the program's vessels in the project area may result in direct and indirect effects due to wake turbulence, sediment resuspension, physical impact with propellers, and discharge of pollutants from the motor's exhaust and lubrication systems.

e. *Beneficial Effects*

Reductions in the percentage of water hyacinth infested waterways theoretically will result in better flows through these waterways, re-establishment of native aquatic vegetation, and recolonization of habitats with native invertebrate species. These changes should result in positive effects on the suitability of the Delta waterways for salmonid rearing and migration. Although these benefits are stated in the DBW BA, definitive data was not given to support this claim and hence must be taken as potential benefits rather than actual benefits.

f. *Potential Extent of Exposure*

The proposed spraying seasons for the WHCP (2006 - 2010) is the 8-month period from April through November in the action area (Delta plus San Joaquin River areas). This treatment period would overlap at least 1 month of adult winter-run Chinook salmon migration through the Delta (22 percent) and at least 2 months of the juvenile winter-run Chinook salmon emigration (29 percent); a majority of the spring-run Chinook salmon adult migration (66 percent) and some juvenile spring-run Chinook salmon emigration (16 percent), 2 months (33 percent) of the juvenile Central Valley steelhead migration through the Delta and 100 percent of the adult Central Valley steelhead emigration. During juvenile out-migration, the winter-run Chinook salmon are at the sub-yearling stage (age zero), spring-run Chinook salmon are at the yearling stage (age 1), and Central Valley steelhead smolts are post-yearlings (age 1.5 – 2 years).

Segments of the North American green sturgeon southern population are expected to be in the waters of the Delta year round. NMFS anticipates that juvenile green sturgeon may be rearing in the channels of the Delta for the first few years of their life before migrating to marine waters as young adults. Adult green sturgeon must transit the Delta in late winter and early spring on their way upstream to spawning grounds in the upper Sacramento River and return through the Delta after spawning is completed in July. The length of time spent in the Delta during these migrations is unclear at this time, but may span several weeks to months and will likely occur during the eight-month period of the WHCP application season.

5. Toxicity of WHCP Herbicides

Water hyacinth is a floating macrophyte, thus the herbicides are applied by spraying the foliage of the plant above the surface of the water. A conservative estimate of the amount of herbicide entering the water column under normal conditions is approximately 10 to 20 percent of the sprayed volume (Anderson 1982).

a. *Weedar®*

Under the WHCP, Weedar® (2,4-D) will be applied at the rate of 2 to 4 quarts per acre (or 4 pounds equivalent per acre) with an instantaneous concentration of 1,200 to 9,600 parts per million (ppm) from the sprayer unit nozzle (actual concentration of active ingredient is 46.8 percent therefore 560 ppm to 4,800 ppm). Instantaneous field concentrations for the herbicide were calculated by DBW to be 1.50 mg/L to 3.10 mg/L in 1 acre-foot of water, and 150 µg/L to 310 µg/L per 10 acre-feet of water if all of the herbicide were to enter the water and complete mixing were to occur. However, actual field concentrations are likely to be much different. Less than 10 to 20 percent of the herbicide enters the water column from the overlying water hyacinth mat, but mixing is neither instantaneous nor homogenous. In addition, complete mixing will only occur after an appreciable time lag, and herbicide concentrations may be substantially higher in the microzone near the surface of the water directly beneath the treated vegetation.

The typical Weedar® concentrations found in the field are expected to be much less than the expected acute toxicity levels (LC_{50}) for 96-hour exposure studies. The 96-hour LC_{50} for 2,4-D for rainbow trout (*O. mykiss*) ranges from ~100 mg/L (Johnson and Finley 1980) to more than 1000 mg/L (Doe *et al.* 1988). The formulation of 2,4-D has been shown to affect toxicity, with the acid and amine forms considerably less toxic to different species of salmonids than the ester formulations (Meehan *et al.* 1974). The levels of toxicity of 2,4-D have been shown to be affected by ambient environmental pH, with the toxicity of the compound decreasing with increasing pH. This is due to the degree of dissociation of the acidic herbicide (Doe *et al.* 1988). Water hardness has also been implicated as a factor in affecting 2,4-D toxicity to salmonids. Hard water was shown to reduce the toxicity of the 2,4-D to different species of salmonids (Wan *et al.* 1991). Invertebrates have been shown to have differing sensitivities to 2,4-D (George *et al.* 1982, Sarkar 1991, and Abdelghani *et al.* 1997) and are frequently more sensitive to 2,4-D than fish.

Physiological and morphological alterations have been seen in fish exposed to 2,4-D. Common changes seen in physiological parameters are changes in enzyme activity levels (Nešković *et al.*, 1994). Exposure to 2,4-D has also been shown to cause morphological changes in gill epithelium in carp. These changes include lifting of the gill epithelium and clubbing of gill filaments, but are considered non-lethal if the fish is removed to clean water for recovery (Nešković *et al.* 1994). In field conditions this would be equivalent to swimming to an untreated area or the herbicide concentration falling off to negligible levels. Carpenter and Eaton (1983) investigated the metabolism of 2,4-D in rainbow trout after injection, and found that almost 99 percent of the compound is excreted in the urine as unchanged 2,4-D, with a half-life of only 2.4 hours. Less than 1 percent was found in the bile of treated fish, presumably as a conjugated metabolite. Similar results were shown for metabolic studies in channel catfish (*Ictalurus punctatus*) where 2,4-D was administered orally (Plakas *et al.* 1992). The responses described in the references above all occurred at considerably higher exposure concentrations than are expected to be seen in the WHCP applications in the Delta.

NMFS has queried the EPA's toxicology database and has not found any citations for sturgeon exposure to 2,4-D. Therefore, NMFS will assume that green sturgeon will be protected by the most sensitive LC_{50} values found in the database for fish exposures to 2,4-D.

Assuming a worst case situation, using the highest predicted environmental concentration (3.1 mg/L) and the lowest LC_{50} for salmonids (100 mg/L), the ambient environmental concentration of 2,4-D at the time of application is still approximately 32 times lower than the 96-hour LC_{50} for salmonids. Furthermore, the concentration of 2,4-D is expected to decrease through dilution and mixing by local water movement. Weedar® is also readily degraded in aquatic systems; its decomposition is enhanced with increased levels of nutrients, sediment loads, and dissolved organic carbon levels. Under field conditions, Weedar® is expected to have a half-life of several days to several weeks (Extoxnet 2001). The environmental fate characteristics of 2,4-D and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids (and presumably green sturgeon) which would lead to death immediately following herbicide applications.

However, sublethal effects are of concern. As mentioned previously, these are the category of effects that are most likely to occur during this program. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects produce less obvious effects on behavior, biochemical and/or physiological functions and the histology of the fish. In addition, potential narcosis in exposed fish can lead to negative effects including increased predation and death as described above. Degradation of critical habitat is expected to occur due to decreases in DO, decreases in the invertebrate standing population which reduces the forage base available to the juvenile salmonids and changes in water quality, particularly ambient water temperature due to a decrease in vegetated cover. In addition, changes in the sensitivities of fish to other contaminants, particularly pesticides and other aromatic hydrocarbons, may increase the mortality of exposed fish. Furthermore, recent medical studies in humans have shown correlations with the usage of herbicides, particularly phenoxy acetic acid herbicides (*e.g.* 2,4- D) to increases in spontaneous abortions (Arbuckle *et al.* 2001) in Ontario farm populations, presence of phenoxy residues in Ontario farmers' sperm (Arbuckle *et al.* 1999), parkinsonism from glyphosate exposure (Barbosa *et al.* 2001), short term decreases in immunological indices in farmers exposed to phenoxy herbicides (Faustini *et al.* 1996) and an increased risk of non-Hodgkin lymphoma from herbicide and pesticide exposures (Lynge 1998, Hardell and Eriksson 1999, McDuffie *et al.* 2001). The epidemiological data for humans exposed to herbicides would indicate that there is sufficient concern to warrant restricted usage of the compounds in aquatic environmental settings until more extensive physiological research is conducted.

b. *Rodeo®*

Under the WHCP, Rodeo® will be applied at the rate of 0.75 to 1.0 gallon of herbicide per 100 gallons of water with an instantaneous concentration of 7,200 to 9,600 ppm from the sprayer unit nozzle (actual concentration of active ingredient is 53.8 percent therefore 3,900 ppm to 5,200 ppm). Instantaneous field concentrations for the herbicide were calculated by DBW to be 2.3 mg/L to 3.10 mg/L in 1 acre-foot of water, and 230 μg/L to 310 μg/L per 10 acre-feet of water if all of the herbicide were to enter the water and complete mixing were to occur. However, actual field concentrations are likely to be different than the theoretical concentrations. DBW believes that only 10 to 20 percent of the herbicide enters the water column after spraying the exposed foliage of the floating water hyacinth mats. The volume of herbicide that does enter the water column will only have complete mixing after an appreciable time lag as water current movements disperse the herbicides within the treatment area. Thus, herbicide concentrations may be substantially higher in the microzone near the surface of the water following the initial movement of the herbicides from the overlying water hyacinth mat into the water body beneath them.

Typical field concentrations of Rodeo® are expected to be less than the acute 96-hour LC_{50} for glyphosate, the active ingredient of the herbicide Rodeo®. However the acute toxicity levels for the formulated mixture found in Rodeo® are higher than that for glyphosate alone. This has been attributed to the addition of surfactants to the mixture. The 96-hour LC_{50} for Rodeo®, calculated as the glyphosate acid for rainbow trout and Chinook salmon ranges from 130 mg/L to 140 mg/l in soft water to 210 mg/L to 290 mg/L in hard water for rainbow trout and Chinook salmon respectively (Mitchell *et al.* 1987a). Wan *et al.* (1989) also found a correlation between water hardness and toxicity for five species of salmonids (coho, chum, Chinook, and pink salmons and rainbow trout [*Oncoryhnchus* spp]). In soft water, Chinook salmon and rainbow trout had similar sensitivities to the herbicide, 19 mg/L to 10 mg/L respectively as glyphosate, and 33 mg/L as Roundup® (a terrestrial formulation of the aquatic herbicide Rodeo® with different surfactants). However in hard water, the LC_{50} for glyphosate was 197 mg/L and 211 mg/L for rainbow trout and Chinook salmon, respectively, considerably less toxic than in soft water. Conversely, the Roundup® formulation was more toxic in hard water, with an LC_{50} equal to 14 mg/l and 17 mg/L for trout and salmon respectively. Folmar *et al.* (1979) found the 96-hour LC_{50} for several different invertebrate and fish species, including rainbow trout. Acute toxicities to rainbow trout were 8.3 mg/L for Roundup® and 140 mg/L for technical glyphosate. The toxicity for the surfactant alone was similar to that of Roundup®, 2.0 mg/L versus 8.3 mg/L for Roundup®.

Folmar *et al.* (1979) also investigated the effects of glyphosate on the reproductive success and behavior of rainbow trout. No significant effects were detected between the control fish and those exposed to the glyphosate in either their gonadal somatic index or fecundity when exposed to 2 mg/L of glyphosate for 12 hours followed by a 30-day recovery period in freshwater. The data found in Folmar *et al.* (1979) indicates that eggs of rainbow trout are less sensitive to the toxicity of Roundup® than other life stages. This is an expected result as the water hardening of the egg's chorion prevents large molecules from crossing into the interior of the egg. After hatching, toxicity increased at the yolk-sac stage and early swim up stages, but decreased in the fingerling stage, as fish grew larger. The values for the 96-hour LC_{50} exposures are as follows:

eyed eggs – 16 mg/L; sac-fry –3.4 mg/L; swim-up fry – 2.4 mg/L; fingerling (1.0 g) - 1.3 mg/L; and fingerling (2.0 g) – 8.3 mg/L. Rainbow trout also did not avoid concentrations of the isopropylamine salt of glyphosate up to 10 mg/L (Folmar 1976, Folmar *et al.* 1979). Morgan *et al.* (1991) found similar reactions of rainbow trout fry exposed to Vision®, a glyphosate based formulation with either 10 percent or 15 percent proprietary surfactant with similar function and use to Roundup®. The nominal concentration that elicited a threshold avoidance reaction from the test fish were 54 ppm for Vision-15 and 150 ppm for Vision-10, roughly two times the LC_{50} for the fish. Threshold effects for alterations in the fish's behavior where observed at 13.5 ppm for Vision-15, and 37.5 ppm for Vision-10 following 24 hours of exposure. These changes were characterized by erratic, gyrating swimming at 24 hours, with the fish eventually becoming moribund at 48 hours.

Physiological studies conducted by Mitchell *et al.* (1987b) on coho salmon showed no apparent adverse effects of exposure of up to 2.3 mg/L of Roundup® in the seawater adaptation of the fish. There were no significant differences in the biochemical and morphological parameters measured in this study between control and treated fish (hematocrit, condition factor, length or weight, or ionoregulatory gill enzymes). Similar findings were made by Janz *et al.* (1991) using the glyphosate herbicide Vision®. Their studies reported that four-hour exposures to sublethal concentrations of Vision did not appear physiologically stressful to juvenile coho salmon, as indicated by secondary stress responses (*i.e.* increased oxygen consumption, plasma glucose and lactate levels, hematocrit and leukocrit). Rainbow trout exposed for two months at concentrations up to 100 g/L of Vision® exhibited no significant effects in foraging behavior, growth, liver tumors, or gill lesions (Morgan and Kiceniuk 1992). However one study did show immunotoxicity to sublethal levels of glyphosate. At concentrations of 2.8 mg/L, El-Gendy *et al.* (1998) showed that exposure for 96-hours could significantly alter lymphocyte proliferation, humoral and cell mediated immunity and protein synthesis in tilapia for up to four weeks after exposure. It should be noted that these responses are rather gross physiological indicators and that few studies have examined cellular or molecular indices of toxicological effects.

NMFS has queried the EPA's toxicology database and has not found any citations for sturgeon exposure to glyphosate based herbicides. Therefore, NMFS will assume that green sturgeon will be protected by the most sensitive LC_{50} values found in the database for fish exposures to glyphosate based herbicides.

Assuming the worst case scenario, the highest instantaneous concentration (3.10 mg/L) and the lowest salmonid LC_{50} for Rodeo® (130 mg/L to 210 mg/L; soft water, hard water), the ambient environmental concentration of Rodeo® at the time of application is still approximately 42 to 68 times lower than the 96-hour LC_{50} for Rodeo® exposure to salmonids. Furthermore, the concentration of glyphosate is expected to decrease due to mixing and dilution in Delta waters after application (but see above also). Glyphosate will also be adsorbed to particulate matter suspended in the water and onto sediments on the bottom of the treated waterways. Bacterial degradation will remove glyphosate from the system and metabolize it to simple carbon compounds. The half-life for glyphosate in aquatic environments is on the order of days to weeks (Extoxnet 2001). The environmental fate characteristics of Rodeo® and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acutely lethal toxicity levels for listed salmonids (and presumably green sturgeon) which would lead to death immediately following herbicide applications.

As previously stated for the herbicide 2,4-D, the sublethal effects of glyphosate and the surfactants used to enhance its penetration of the plant cuticle are the most likely toxicological endpoints that will be demonstrated by salmonids and green sturgeon exposed to this herbicide application. The appearance of acute lethality following herbicide application under the WHCP is unlikely, but long term health and behavioral effects can not be ruled out based on the human medical data.

c. *Reward®*

The estimated instantaneous environmental concentration of Reward® at the application rate used in the WHCP (2.8 lbs. per acre) will be approximately 0.37 ppm diquat. The 96-hour LC_{50} for rainbow trout ranges from 11.2 mg/L (Gilderhus 1967) to 21 mg/L (Worthington and Hance 1991). The 8-hour LC_{50} for diquat dibromide is 12.3 mg/L for rainbow trout and 28.5 mg/L for Chinook salmon (Pimental 1971). However, studies by Paul *et al.* (1994) found that diquat was toxic to larval fish as low as 0.74 ppm (96-hour exposure) and would indicate that early life stages may be much more sensitive to diquat than older fish. Folmar's studies (1976) indicated that rainbow trout did not avoid diquat at concentrations up to 10 mg/L (highest concentration tested), nearly the lethal concentration for this species. The concentration of diquat in the Delta waters is expected to decrease rapidly after initial application due to the extensive adsorption of the compound to suspended particulate matter in the water column and sediment on the bottom. The half-life for diquat dibromide can be as little as 48 hours in water (Extoxnet 2001). However, diquat dibromide may persist for longer periods in the bottom sediments. Diquat residues were found 21 days after application in an artificial lake, 1 percent in the water and 19 percent adsorbed to sediments (Extoxnet 2001). Diquat that is adsorbed to particulate matter is purportedly biologically unavailable to aquatic organisms.

Assuming the worst case scenario, using the highest predicted environmental concentration (0.37 ppm) and the most sensitive LC_{50} (0.74 ppm), the instantaneous diquat concentration is still two times lower than the most sensitive LC_{50} values which are for larval fish. The instantaneous concentration is almost 77 times lower than the published LC_{50} values for Chinook and 31 times lower than those for rainbow trout are. The environmental fate characteristics of Reward® and the application rates used in the WHCP would indicate that the concentration levels of the herbicide achieved in Delta waters should be significantly below the acute toxicity levels of listed salmonids.

As mentioned previously, sublethal effects are of concern. Oxidative stress in exposed fish can be expected from the application of diquat dibromide. This reactive compound is subject to redox cycling in which highly reactive oxygen radicals are formed during the regeneration of the parent compound from the reactive intermediate metabolite. Either the reactive intermediate metabolite of the parent diquat compound, or the reactive oxygen radicals can cause deleterious effects on the organism via covalent binding to DNA or proteins thus forming adducts or oxidation of DNA, lipids or proteins within the organism (Schlenk and Di Giulio 2002). The degree to which the stress will manifest itself in the exposed organism depends on the status of the organisms protective pathways (super oxide dismutase, glutathione reductase and catalase) and their ability to convert the reactive oxygen radicals to less potent forms.

d. *Surfactants*

Surfactants are frequently toxic in their own right. The surfactant R-11 has a 96-hour LC_{50} of 3.8 ppm for rainbow trout, making it considerably more toxic than the glyphosate it is commonly mixed with (Diamond and Durkin 1997). Curran *et al.* (2003) found that R-11 was significantly more toxic to smaller rainbow trout (0.39 g) than it was to larger fish (15.46 g) when the LC_{50} of each size was compared (5.19 ppm v. 6.57 ppm) and that EPA test criterion size (<3g) indicates that differences in fish size may cause differences in the 96-hour LC_{50} as great as 200 percent. Experimental data indicates that the surfactant Agri-Dex is approximately 300 times less toxic than R-11 (3.8 ppm v. >1000 ppm) when their 96-hour LC_{50} values are compared (Diamond and Durkin 1997). Furthermore, the surfactant R-11 has been implicated as causing endocrine disruption in fish and amphibians as one of its constituents is a nonylphenol polyethoxylate (NPE). Nonylphenols are weakly estrogenic, and have been shown to cause endocrine disruption under laboratory conditions at low doses (20 ppb) (United Kingdom Marine Special Areas of Conservation Project 2003). Exposure of male fish to these compounds, nonylphenols and octylphenols, has induced the formation of the lipoprotein vitellogenin (Jobling *et. al.* 1996, Blackburn *et. al.* 1999). Vitellogenin is a lipoprotein normally produced by females and found in the yolk of the eggs. These compounds are lipophilic and have the potential to accumulate in fatty tissues of aquatic organisms. However, the same lipophilic characteristics will also cause the compounds to be absorbed into organic biofilms surrounding particulate matter. These alkylphenols will tend to partition on to particulate matter and, to a large extent, be incorporated into the underlying sediments (Blackburn *et al.* 1999). Chronic toxicity values (No Observed Effects Concentrations) for NPEs and their metabolites have been shown to occur as low as 6 ppb in fish and 3.9 ppb for aquatic invertebrates (Environment Canada 2003). In comparison to the project's herbicides, the surfactant R-11 is more toxic and has a range of effects that present themselves in the low parts per billion concentration range.

As described in the previous sections concerning the herbicides, sublethal effects from the surfactants used in the WHCP may ultimately increase the likelihood of mortality of salmon and steelhead. Sublethal effects are characterized as those that occur at concentrations that are below those that lead directly to death. Sublethal effects may impact the fish's behavior, biochemical, and/or physiological functions, and create histological alterations of the fish's anatomy. In addition, changes in the sensitivities of fish to other contaminants (*i.e.*, chemical synergism), particularly pesticides and other aromatic hydrocarbons, may increase the mortality of exposed fish. Degradation of habitat is expected to occur due to decreases in DO level due to water hyacinth decomposition, decreases in native vegetative cover, decreases in the invertebrate standing population which reduces the forage base available to juvenile salmonids, and changes in ambient water temperature due to changes in the amount of vegetative cover.

e. Bioaccumulation of Herbicides

The high water solubility of Weedar® indicates that the active ingredient (2,4-D) is not likely to bioaccumulate in fish tissues, or undergo maternal transfer into developing ovaries and associated eggs. Bluegills and channel catfish absorbed only 0.5 percent of radio-labeled 2,4-D during exposures to 2mg/L of the compound in laboratory studies. The amount of 2,4-D absorbed was maximal after 24 hours of exposure, and did not change significantly for the next 7 days. Bluegills administered 2,4-D via intraperitoneal injection, excreted 90 percent of the dose within 6 hours of treatment (Sikka *et al.* 1977). Rainbow trout excrete almost 99 percent of injected 2,4-D in their urine as the unchanged compound, with a half-life of 2.4 hours (Carpenter and Eaton 1983).

There is very low potential for glyphosate (Rodeo®) to bioaccumulate in the tissues of aquatic organisms due to its high water solubility. Furthermore, glyphosate is broken down by microbial actions fairly rapidly, and is subject to photodegradation in the water column. Like Weedar®, Rodeo® strongly adsorbs to particulate matter in the water column and to sediments on the bottom.

There is little bioconcentration of diquat dibromide in fish (Extoxnet 2001). A study on the metabolism and toxicokinetics of diquat dibromide in channel catfish estimated the half-life for diquat to be 35.8 hours (Schultz *et al.* 1995), indicating fairly rapid elimination, and little potential for bioaccumulation.

The nature of salmonid life history in the Delta also diminishes the likelihood of bioaccumulation of the herbicides applied in the WHCP. Listed species of salmonids are transitory in their use of the Delta, residing for only a few weeks to months in the Delta before emigrating to the ocean.

f. Removal of Native Submerged and Emergent Aquatic Vegetation

Native submerged and emergent vegetation may be harmed by the application of herbicides during the WHCP. However, NMFS believes that the harm to native vegetation will be temporary, as new colonizing plants take hold in the treated area. Removal of the thick mats of water hyacinth will allow light penetration to submerged plants in areas previously shaded by these mats. Likewise, the floating mats of water hyacinth will not crowd out emergent plants, which smother and abrade the native plants. Treated areas will also allow the native plants the opportunity to re-colonize these areas without competing with the water hyacinth for space and resources. During periods of juvenile salmonid migration, treated areas may not provide the necessary vegetative cover or food resources needed by the fish. Treatment protocols could possibly magnify this impact as adjacent areas could be treated within 48 hours, thereby increasing the areas devoid of aquatic vegetation or having compromised water quality. NMFS believes that these localized effects will reduce the probability of survival of juveniles emigrating through or rearing in the treatment area. Adjacent untreated acreage could be available to provide shelter and foraging for the juvenile salmonids as they move out of the treated area. However, expenditures of valuable metabolic reserves will have to be utilized for swimming to these new areas, making these reserves unavailable for other physiological needs like growth or smoltification. This shift in the utilization of metabolic energy stores has the potential to decrease the health and hence the survivability of the juvenile salmonid.

g. Declines in the Abundance of Invertebrate Food Resources

The chemical compounds proposed for use in the WHCP should not reach levels toxic to invertebrates if they are applied at the labeled rates. Regions of low DO caused by drifting mats of decaying vegetation or smothering of benthic substrate may cause a localized decrease in populations and diversity of invertebrates. This would temporarily affect salmonid and green sturgeon foraging success in treated areas. Invertebrates have limited ability to migrate out of the treatment area, and thus are more susceptible to the effects of the DO levels. Following treatment, new populations of invertebrates will re-establish themselves through larval re-colonization of the area as soon as habitat conditions are suitable for their growth. Therefore, as a result of the WHCP, portions of the critical habitats for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead will be negatively impacted until water quality is re-established in the treated areas and the native invertebrate species can re-establish themselves in sustainable populations.

VI. CUMULATIVE EFFECTS

For purposes of the ESA, cumulative effects are defined as the effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 CFR §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultations pursuant to section 7 of the ESA.

Non-Federal actions that may affect the action area include ongoing agricultural activities and increased urbanization. Agricultural practices in the Delta may adversely affect riparian and wetland habitats through upland modifications of the watershed that lead to increased siltation or reductions in water flow in stream channels flowing into the Delta. Unscreened agricultural diversions throughout the Delta entrain fish including juvenile salmonids. Grazing activities from dairy and cattle operations can degrade or reduce suitable critical habitat for listed salmonids by increasing erosion and sedimentation as well as introducing nitrogen, ammonia, and other nutrients into the watershed, which then flow into the receiving waters of the Delta. Stormwater and irrigation discharges related to both agricultural and urban activities contain numerous pesticides and herbicides that may adversely affect salmonid reproductive success and survival rates (Dubrovsky *et al.* 1998, 2000, Daughton 2003).

The Delta and East Bay regions, which include portions of Contra Costa, Alameda, Sacramento, San Joaquin, Solano, Stanislaus, and Yolo Counties, are expected to increase in population by nearly 3 million people by the year 2020 (California Commercial, Industrial, and Residential Real Estate Services Directory 2002). Increases in urbanization and housing developments can impact habitat by altering watershed characteristics, and changing both water use and stormwater runoff patterns. The project site is within the region controlled by San Joaquin County Council of Governments, and the cities of Brentwood, Antioch, Oakley, Lathrop, Modesto, Turlock, Merced, Fresno, and Sacramento. The General Plans for the cities of Stockton, Brentwood, Antioch, Oakley and their surrounding communities anticipate rapid growth for several decades to come, as do the other more established communities. The anticipated growth will occur along both the I-5 and US-99 transit corridors in the east, and Highway 4 in the west.

Increased urbanization also is expected to result in increased wave action and propeller wash in Delta waterways due to increased recreational boating activity. This potentially will degrade riparian and wetland habitat by eroding channel banks and mid-channel islands, thereby causing an increase in siltation and turbidity. Wakes and propeller wash also churn up benthic sediments thereby potentially resuspending contaminated sediments and degrading areas of submerged vegetation. This in turn would reduce habitat quality for the invertebrate forage base required for the survival of juvenile salmonids. Increased recreational boat operation in the Delta is anticipated to result in more contamination from the operation of engines on powered craft entering the water bodies of the Delta. In addition to recreational boating, commercial vessel traffic is expected to increase with the redevelopment plans of the Port. Portions of this redevelopment plan have already been analyzed by NMFS for the West Complex (formerly Rough and Ready Island) but the redevelopment of the East Complex, which currently does not have a Federal action associated with it, will also increase vessel traffic as the Port becomes more modernized. Commercial vessel traffic is expected to create substantial entrainment of aquatic organisms through ship propellers as the vessels transit the shipping channel from Suisun Bay to the Port and back again. In addition, the hydrodynamics of the vessel traffic in the confines of the channel will create sediment resuspension, and localized zones of high turbulence and shear forces. These physical effects are expected to adversely affect aquatic organisms, including both listed salmonids and North American green sturgeon resulting in death or injury.

VII. INTEGRATION AND SYNTHESIS

The degree to which Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead may be impacted by the WHCP is a function of their presence within the action area. The proposed period of implementation of the WHCP is from April 1 through November 30, which will overlap with more than half of the migration periods for the two Chinook salmon listed ESUs and the Central Valley steelhead DPS. The period of greatest overlap with the presence of listed juvenile salmonids in the Delta is during the higher flow periods of spring (*e.g.*, from April through June) and fall (*e.g.*, October 1 through November 30). North American green sturgeon are anticipated to be year round residents within the Delta portion of the action area and therefore will be present for the entire application season in the Delta region (April through October 15). The upstream reaches of the San Joaquin River from Mossdale to Hills Ferry are expected to potentially have listed Central Valley steelhead present during the April through June period, based on water temperature profiles and emigration patterns. The upper reaches of the Tuolumne and Merced Rivers above their confluences with the San Joaquin River but below the first impassable barrier (La Grange Dam or Merced Falls Dam respectively) may have juvenile Central Valley steelhead present year round based on the cooler temperatures available below the dams and the life history of steelhead. However, water conditions that favor steelhead residency (*i.e.* faster flows and cooler water temperatures) do not favor water hyacinth infestations. Infestations in these reaches are typically off channel sloughs or isolated water bodies set off from the main channel by receding water levels.

Based on the foregoing analysis, NMFS anticipates that applications of Reward®, Weedar®, or Rodeo® to the waters of the Delta and its tributaries during the WHCP treatment seasons in an effort to control water hyacinth will not result in acute lethal effects to listed salmonids, unless fish are present in the immediate area during or immediately after the herbicide is applied. Nonetheless, there is a potential for loss of a certain fraction of the migrating population that is exposed to the toxicants. Although fish should not be present in the cores of water hyacinth mats, they may be present along the periphery of the mats, utilizing them for cover from overhead predators. Thus, fish may be exposed to lethal or sublethal concentrations of herbicides that are applied to the margins of the mat or to herbicides present in the water column directly below the mat or flowing out of the area of application.

The most important impacts of the WHCP are expected to occur to juvenile salmonids and green sturgeon, and include sublethal effects and effects to habitat. As stated in Rand (1995), sublethal effects to listed salmonids can be expected to take the form of behavioral, physiological, biochemical, or histological changes in the exposed fish. These changes may not be immediately lethal, but can cause fish to exhibit impaired behaviors (*e.g.*, narcosis) or eventually develop a lesser level of physical health, thus reducing their chances of survival as compared to unexposed fish. Possible consequences include loss of equilibrium, reduced swimming ability, and impaired predator avoidance behavior, which could lead to increased predation risk or reduced foraging ability. Chemical synergism between the WHCP herbicides and other contaminants in the Delta could occur and exacerbate these effects.

The WHCP is expected to result in several temporary degraded habitat conditions. These are expected to include physical disturbance, elevation of water temperature caused by reduced shading, reduction of DO levels resulting from decaying water hyacinth, reduction in the invertebrate forage base for juvenile salmonids and green sturgeon, and reduction of native vegetation which juvenile salmonids may utilize for cover. Even though juvenile salmonids should be able to leave or avoid areas of degraded habitat, they may need to expend valuable metabolic energy to do so. This could result in depleted energy stores that could have been used for other physiological needs, such as growth or smoltification.

As stated previously in the project description, the WHCP proposes to treat 367 possible sites for water hyacinth infestation (see Table 3). These sites range between one to two miles in length. Treatment sites are located throughout the Delta, including portions of the Sacramento River, Steamboat Slough, and Sutter Slough, as well as most of the San Joaquin River watershed between the first dam on each tributary and its confluence downstream with the mainstem of the San Joaquin River and then north along the mainstem of the river to the Delta. Over the last 3 years approximately 2,500 acres were treated annually. The geographical coverage of the WHCP overlaps with the known migration corridors for all three listed salmonids as well as the fall/late fall run of Chinook salmon in the Central Valley. However, DBW has a limited number of spray boats (*i.e.*, in 2002, four full time and three part time crews and boats were used) that can be active on any given weekday. Therefore, only a fraction of the 367 sites can be treated in any given day, and not all sites treated may be within areas expected to support salmonids. Each crew is capable of treating at a maximum 50 acres per a day if conditions are optimal and they work overtime. However, due to environmental and logistical constraints, the treatment acreage is frequently less. In addition to the low number and area of coverage of daily sites for the treatment program, only the waters near the periphery of the water hyacinth mat will have elevated herbicide concentrations capable of having toxicological effects on the fish. Even though the interior of the mat will have similar elevated concentrations of herbicides following treatment, it is unlikely that any salmonids will be present within the interior due to its low ambient DO levels. Therefore the total area of Delta waters likely to have negative effects on fish during the period of elevated concentrations is far smaller than 50 acres on any given treatment day. As a result, NMFS reasons that very few listed salmonids will be present within areas of toxicological effect. The duration of elevated herbicidal concentrations in the peripheral waters will depend on the rate of mixing that occurs and the subsequent dilution of the herbicide applied to the mat as well as other physical conditions such as adsorption to suspended matter in the water column and water hardness. The dilution of applied herbicides will occur over a period of minutes to hours, dependent on current velocity, tidal stage, and local water quality. These parameters will invariably change on both a spatial and temporal scale in the described action area. Therefore, NMFS expects that areas with elevated herbicide concentrations will be both small and transient in nature, resulting in low levels of exposure to salmonids migrating through the action area and transitory impacts on critical habitat. Degraded habitat conditions eventually will be attenuated as DO levels increase and invertebrates recolonize treated areas. In addition, the removal of water hyacinth eventually may improve habitat conditions for juvenile salmonids if water flow improves and native vegetation colonizes the treated areas, creating shaded habitat. Similarly, it is not anticipated that individual green sturgeons will congregate in application areas in high enough numbers to represent a significant proportion of the population, but rather will be dispersed throughout the channels of the Delta.

NMFS, in previous consultations with DBW and the USDA-ARS, has given guidance for avoidance of listed fish based on temporal and spatial parameters. NMFS has concluded that certain sections of the project area can be treated with minimal potential for exposing listed salmonids and the proposed green sturgeon starting as early as April 1 of the treatment season. These early start dates allow boat crews from DBW to start control measures early in the water hyacinth's growth cycle. The sections that were chosen by NMFS for early start dates have habitats that are unsuitable for salmonids either due to a lack of circulation (eastside sloughs) or physical barriers to prevent salmonid migration into the application area (South Delta region between temporary barriers after the installation of the Head of Old River Barrier). Early applications in the San Joaquin River watershed are based on hydrologic connections between off channel sloughs and ponds and the main channel and the ambient water temperatures in the system. When there is a lack of hydrologic connection between the off channel water bodies and the main water channel, then NMFS believes that any hyporheic flow between the two bodies will be insufficient to carry herbicides between the two water bodies through the gravel and underlying substrate. When water temperatures have become sufficiently elevated to preclude the presence of listed salmonids (greater than 70 ^{o}F for seven consecutive days and after May 15) then herbicide treatments may be applied in the main channels of the San Joaquin River and its tributaries. DBW has incorporated these guidelines into its application protocol as described in the project description (see section II (C)(5) of this biological opinion).

While there will be negative impacts to a proportion of the listed salmonid populations that are within the immediate vicinity of a herbicidal application at the moment of application or immediately following it, the exact proportion of each ESU affected by the application is difficult to determine since the density of migrating fish and the timing of migration can vary annually and within seasons based on a myriad of factors. However, as discussed above, only a small segment of each listed salmonid race is expected to be actually exposed to concentrations sufficiently elevated to have a negative impact on the individual fish. Effects of primary concern are sublethal, as few or no fish are likely to be directly killed during herbicide application. Sublethal effects such as behavioral changes (*e.g.*, swimming, feeding, attraction, avoidance, and predator-prey interactions), physiological changes (*e.g.*, growth, reproduction, and development), biochemical changes (*e.g.*, blood enzyme and ion levels), and histological changes (*e.g.*, degenerative necrosis of the liver, kidneys, and gill lamellae) are expected in the fish that are exposed to areas of elevated herbicide and surfactant concentrations. However, based on the low likelihood of fish exposure to these levels and the small numbers of salmonids likely affected, this level of impact is not expected to detectably reduce the numbers, reproduction, or distribution of the cohorts affected during each year of treatment. Likewise, green sturgeon are not anticipated to spend any length of time in the localized areas of herbicide applications for water hyacinth control. Green sturgeon are expected to rear primarily in the deeper channels and holes of the Delta with transient foraging movements onto the shallow flats during favorable tides. As previously stated, NMFS could not find any data on herbicide exposure to sturgeon species in the EPA database. Therefore, NMFS will assume that the sturgeon will be no more sensitive than the most sensitive fish species available in the database and based on the current analysis would not show signs of acute toxicity from the herbicide concentrations present in the WHCP.

Critical habitat for Sacramento River winter-run Chinook salmon in the project area is not expected to be adversely modified. The majority of the critical habitat in the project area for this ESU is in the Sacramento River, Steamboat, Cache, and Sutter Sloughs. Although some treatment areas will be in the Sacramento River side of the Delta, WHCP operations will be primarily to the south of these waterways in the central and south Delta regions as well as in the San Joaquin River watershed. Critical habitat for the Central Valley spring-run Chinook salmon ESU includes waterways in the central Delta (North Fork Mokelumne River and Georgiana Slough) and waterways in the northern portion of the Delta. The critical habitat for the Central Valley steelhead DPS includes all waters of the Delta that are accessible to anadromous fish, and habitat below the high water line (*i.e.* tidal flats, commonly inundated riparian zones, *etc*.). Critical habitats for Sacramento River winter-run and Central Valley spring-run Chinook salmon and Central Valley steelhead are not expected to be permanently affected in an adverse manner, but rather on a temporary basis following herbicide treatment. The degraded habitat conditions eventually will be attenuated as DO levels increase and invertebrates recolonize treated areas. The removal of water hyacinth eventually may improve habitat conditions for juvenile salmonids if water flow improves and native vegetation colonizes the treated areas, creating shaded habitat and diverse foraging opportunities for juvenile salmon. Therefore, the EDCP is not expected to appreciably reduce the conservation value of designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead. No critical habitat has been proposed for green sturgeon at this time.

VIII. CONCLUSION

A. Formal Consultation

After reviewing the best available scientific and commercial information, the current status of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead, the environmental baseline, the effects of the proposed WHCP, and the cumulative effects, it is NMFS' biological opinion that the WHCP, as proposed, is not likely to jeopardize the continued existence of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead, or result in the destruction or adverse modification of the designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead.

B. Conference Consultation

After reviewing the best available scientific and commercial information, the current status of the southern DPS of North American green sturgeon, the environmental baseline, the effects of the proposed WHCP, and the cumulative effects, it is NMFS' biological opinion that the WHCP, as proposed, is not likely to jeopardize the continued existence of the southern DPS of North American green sturgeon.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by NMFS as an act which kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement (ITS).

The measures described below are non-discretionary and must be undertaken by the USDA-ARS so that they become binding conditions of any grant or permit issued to DBW or their agents, as appropriate, for the exemption in section 7(o)(2) to apply. The USDA-ARS has a continuing duty to regulate the activity covered in this ITS. If the USDA-ARS: (1) fails to assume and implement the terms and conditions of the ITS; and/or (2) fails to require the DBW or its agents to adhere to the terms and conditions of the ITS through enforceable terms that are added to the permit or grant document, the protective coverage of section 7(o)(2) may lapse. In order to monitor the impact of incidental take, the USDA-ARS and its agents must report the progress of the action and its impact on the species to NMFS as specified in this ITS (50 CFR §402.14[i][3]).

While some measures described below are expected and intended to avoid, minimize, or monitor the take of North American green sturgeon, the prohibitions against taking of listed species in section 9 of the ESA do not apply to proposed North American green sturgeon unless and until the species is listed. However, NMFS advises the USDA-ARS to consider implementing the following reasonable and prudent measures for proposed North American green sturgeon. If this conference opinion for North American green sturgeon is adopted as a biological opinion following a listing, the measures for North American green sturgeon, with their implementing terms and conditions, will be nondiscretionary.

A. Amount or Extent of Take

NMFS anticipates that the proposed WHCP will result in the incidental take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon.

The incidental take is expected to be in the form of death, injury, harassment, and harm from sources such as herbicide exposure, behavioral modifications, increased susceptibility to contaminants in the aquatic system, and depleted DO. Direct take of salmonids from the DBW's activities (*e.g.*, exposure to herbicide applications) is expected to occur primarily to listed salmonids and only during the months of April and May, when listed salmonids are most likely to be present in the Delta. Take from extended changes to the action area (*e.g.*, reductions in forage base species and changes in plant communities) are expected to affect listed salmonids from November 1 through May 31, which includes the entire period when individuals from one or more of the listed ESUs or DPSs may be expected to occur in the action area.

North American green sturgeon are known to spawn only in the Sacramento River drainage. Therefore, NMFS assumes that adverse effects to green sturgeon are most likely to occur in the lowermost portions of the Sacramento and San Joaquin River channels during the application season. Green sturgeon are expected to occur in the action area year-round, although it is anticipated that the highest densities will occur from April through October. Therefore, take from project activities is most likely to occur from April through October during the proposed work window. The occupation of benthic habitat by green sturgeon is expected to increase their vulnerability to water quality changes due to decaying vegetation as compared to listed salmonids.

The numbers of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon taken will be difficult to quantify because dead, injured, or impaired individuals will be difficult to detect and recover. Take is expected to include:

1. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead fry and juveniles, as well as all North American green sturgeon killed from exposure to lethal and sublethal concentrations of diquat, glyphosate, 2,4-D or surfactants applied to waters of the Delta and the San Joaquin River basins.

2. All Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead fry and juveniles, as well as all North American green sturgeon harmed, harassed, or killed from altered habitat conditions, increased

predation levels, and reductions in health as a result of chemical herbicide exposure or activities resulting from the implementation of the WHCP.

B. Effect of the Take

In the accompanying biological and conference opinion, NMFS determined that the level of anticipated take will not result in jeopardy to the species or destruction or adverse modification of designated or proposed critical habitat.

C. Reasonable and Prudent Measures

Reasonable and Prudent Measures (RPMs) are non-discretionary measures to minimize take that may or may not already be part of the description of the proposed action. They must be implemented as binding conditions for the exemption in section 7(o)(2) to apply. The USDA-ARS has the continuing duty to regulate the activities covered in this incidental take statement. If the USDA-ARS fails to adhere to the terms and conditions of the incidental take statement, or fails to retain the oversight of its contractor(s) to ensure compliance with these terms and conditions, the protective coverage of section 7(o)(2) may lapse.

NMFS believes that the following RPMs are necessary and appropriate to minimize take of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead resulting from implementation of the action. These reasonable and prudent measures would also minimize adverse effects on designated critical habitat for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. Implementation of these actions will also serve to avoid or minimize adverse effects upon North American green sturgeon, should they be eventually listed, by the actions of the WHCP.

1. Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon from chemical control treatment and/or monitoring activities.

2. Measures shall be taken to reduce the impact of DBW’s WHCP boating operations on Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central valley steelhead, and North American green sturgeon.

3. Measures shall be taken by DBW to monitor the operations of the WHCP and the ambient Delta hydrologic conditions.

4. Pending the listing of the southern population of North American green sturgeon, the USDA-ARS and their agents will implement additional measures to avoid, minimize, and monitor incidental take of North American green sturgeon from the actions of the WHCP.

D. Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the Act, the USDA-ARS must comply with the following terms and conditions, which implement the reasonable and prudent measures described above and outline required reporting/monitoring requirements. These terms and conditions are non-discretionary.

1. **Measures shall be taken to reduce impacts to juvenile Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, Central Valley steelhead, and North American green sturgeon from chemical control treatment and/or monitoring activities**.

    a. Restrictions to the timing and places of herbicide applications shall comply with the guidelines indicated in the project description for the WHCP as presented in section II (C)(5) of this biological opinion.

    b. Any winter-run Chinook salmon, spring-run Chinook salmon, and steelhead trout mortalities found at or in the vicinity of a treatment site (*i.e.*, within 400 meters) shall be collected, fork length measured and the body placed in a whirl-pak bag. The bag will be labeled with the time, date, location of capture, and a description of the near-shore habitat type and water conditions and frozen. NMFS, Sacramento office shall be notified as soon as possible of any mortalities at 916-930-3600 and a representative of NMFS will collect the frozen specimen.

    c. DBW staff and their assigned agents must follow all Federal and State laws applicable to the use of the herbicides and any adjuvants and apply them in a manner consistent with the product labeling, the current NPDES General Permit if granted, the Description of the Proposed Action, and determinations from the California Department of Pesticide Regulation.

    d. The use of the adjuvant R-11 shall be reduced to minimize its toxic effects on aquatic organisms where practicable. The less toxic adjuvant, Agri-Dex, shall be used in its place. R-11 may be used in the following defined areas during the appropriate application windows. Within the sites on the San Joaquin River south of the intersection of Merced, Madera, and Fresno Counties (sites 900 to 929), R-11 may be used as an adjuvant between June 1 and October 15. Within the Stone Lakes/Beach Lakes area (sites 221-239), R-11 may be used as an adjuvant between June 1 and October 15. R-11 may not be used as an adjuvant elsewhere in the WHCP application areas.

    e. Fish passage shall not be blocked within treatment areas. Protocols shall be followed to ensure that WHCP operations do not inhibit passage of fish in each area scheduled for treatment or exceed limitations on contiguous treated acreage.

    f. The DBW will provide a copy of each week's Notice of Intent to Jeffrey Stuart, Fishery Biologist, Protected Resources Division, 650 Capitol Mall, Suite 8-300, Sacramento, CA 95814, by the Friday prior to the treatment week. This notification will include the sites scheduled for treatment and a contact person for those sites.

g. Jeffrey Stuart will be the appointed NMFS representative on the Water Hyacinth Task Force (Task Force), and provide technical assistance to the Task Force along with carrying out the duties of a Task Force member. As part of the WHCP Task Force, the NMFS representative will be active in guiding decisions on prioritizing treatment sites in regards to the presence of salmonids.

2. **Measures shall be taken to reduce the impact of DBW's WHCP boating operations on the designated critical habitat of Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead**.

a. USDA-ARS and DBW shall comply with the receiving water limitations of the General Permit issued for the WHCP in regards to oils, greases, waxes, floating material, or suspended material derived from the operation of program vessels or application activities.

b. The USDA-ARS and DBW shall ensure that any mixing of chemicals, or disinfecting and cleaning of any equipment shall be done in strict accordance with the operational protocols of the WHCP and that all equipment is in working order prior to engaging in application activities, including the operation of the program's vessels.

c. Operation of program vessels in shallow water habitats shall be done in a manner that causes the least amount of disturbance to the habitat. Operational procedures for vessels in these habitats should minimize boat wakes and propeller wash.

d. Operation of program vessels shall avoid or minimize to the greatest practicable extent dislodging portions of existing water hyacinth mats that can drift into other areas. This will avoid or minimize new infestations of the weed due to drifting fragments.

3. **Measures shall be taken by DBW to monitor the operations of the WHCP and the ambient Delta hydrologic conditions**.

a. The USDA-ARS shall ensure that the DBW follows a comprehensive monitoring plan designed to collect project operational information. The monitoring plan shall adhere to the requirements of the General Permit and have at a minimum those water quality criteria stated in Attachment B of the permit, *i.e.* data on water temperatures, DO, pH, turbidity, water hardness, electrical conductivity, and chemical concentrations in the application areas as well as other criteria stated in the attachment. Chemical concentrations (including both herbicides and adjuvants) shall have at a minimum, a pre- and post-application water sample taken at the furthest down current site of the application zone. Additional tests, if required by other Federal and State agencies, shall be conducted and the information made available to NMFS. The results of this monitoring program will be used to determine if the DBW is affecting Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead to an extent not previously considered.

b. The USDA-ARS, in coordination with the DBW, shall provide bimonthly (*i.e.*, every other month) monitoring reports of the hydrologic conditions and the amounts of chemical discharges to Jeffrey Stuart, NMFS, Sacramento Field Office. These reports shall also include information on the following parameters:

   i. Pre-treatment and post-treatment measurements on chemical residues, pH and turbidity levels as well as water temperatures and DO concentrations at selected sites in the Delta. These sites shall be reflective of the different water types found in the range of application sites and will be determined by DBW as part of their NPDES permit conditions.

   ii. Receiving water temperatures and DO levels and resultant changes in those conditions resulting from WHCP operations during each month.

   iii. Amounts, types, and dates of application of herbicides and adjuvants applied at each site.

   iv. Visual assessment of pre- and post-treatment conditions of treated sites to determine the efficacy of treatment and any effects of chemical drift on downstream habitats immediately adjacent to the treated sites.

   v. Operational status of equipment and vessels, including repairs and spraying equipment calibrations as needed.

c. The USDA-ARS, in coordination with the DBW, shall summarize the above bimonthly reports into an annual report of the DBW project operations, monitoring measurements and Delta hydrological conditions for the previous treatment year for submission to NMFS by January 31 of each year. The annual report of DBW operations shall also include:

   i. A description of the total number of winter-run and spring-run chinook salmon or steelhead observed taken, the manner of take, and the dates and locations of take, the condition of the Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, or Central Valley steelhead taken, the disposition of fish taken in the event of mortality and a brief narrative of the circumstances surrounding the take of the fish. This report shall be sent to the address given below.

   ii. Listed salmonids or other fish species that are observed to be behaving in an erratic manner shall be reported (see Appendix A).

d. All bimonthly reports and the annual report shall be submitted by mail or Fax to:

NMFS Sacramento Field Office
Attn: Supervisor
650 Capitol Mall, Suite 8-300
Sacramento, California 95814
Fax: (916)930-3629

4. Pending the listing of the southern population of North American green sturgeon, the USDA-ARS and their agents will implement additional measures to avoid, minimize, and monitor incidental take of North American green sturgeon from the actions of the WHCP.

a. The USDA-ARS will monitor the take of green sturgeon, and record such information for their reports to NMFS required under term and condition 3(C), above.

b. If necessary, USDA-ARS and DBW will coordinate with NMFS to alter herbicide application plans to avoid or minimize take of green sturgeon if field observations indicate that take is occurring.

X. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on a listed species or critical habitat or regarding the development of pertinent information.

1. The USDA-ARS and DBW should support anadromous salmonid monitoring programs throughout the Delta to improve the understanding of migration and habitat utilization by salmonids in the Delta region.

2. The USDA-ARS and DBW should support and promote aquatic and riparian habitat restoration within the Delta region, and encourage practices that avoid or minimize negative impacts to salmon and steelhead.

3. NMFS recommends that the USDA-ARS encourage alternate non-chemical controls of water hyacinth and other non-native invasive vegetation in the Delta and its tributaries, in conjunction with a re-vegetation program with native plants in the Delta.

4. NMFS recommends that the USDA-ARS and DBW increase public awareness of the potential threats to proper ecosystem function by exotic species introductions such as water hyacinth.

5. NMFS recommends that the USDA-ARS and DBW pro-actively promote state legislation that takes steps to curb the importation and marketing of water hyacinth, and prevent future exotic species introductions into the state.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, NMFS requests notification of the implementation of any conservation recommendations.

XI. REINITIATION OF CONSULTATION

This concludes formal consultation on the actions outlined in the November 14, 2005 BA from the USDA-ARS and the DBW. This biological opinion is valid for the project described for the years 2006 through 2010. As provided for in 50 CFR§402.16, reinitiation of formal consultation is required where discretionary federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of taking specified in any incidental take statement is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not previously considered; (3) the agency action is subsequently modified in a manner that causes an affect to the listed species that was not considered in the biological opinion; or, (4) a new species is listed or critical habitat is designated that may be affected by the action. In instances where the amount or extent of incidental take is exceeded, formal consultation shall be reinitiated immediately.

XII. REFERENCES

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Appendix A: Tables

Table 2:
Chemical Usage and Acreage Treated during the 2003 through 2005 Treatment Seasons

2003	2,4 - D		Glyphosate		R-11	Agri-dex
Month	Gallons	Acres	Gallons	Acres	Gallons	
April	0	0	0	0	0	0
May	42.69	42.69	90.7	121.16	40.33	0
June	78.08	80.61	105.91	141.96	55.32	0
July	430.45	433.18	38.73	51.83	124.8	0
August	428.75	430.78	46.63	63.19	111.34	0
September	479.78	481.45	49.02	66.64	126.51	0
October	259.37	259.87	35.81	47.74	60.57	0
November	0	0	0	0	0	0
Total	1719.12	1728.58	366.8	492.52	518.87	0

2004	2,4 - D		Glyphosate		R-11	Agri-dex
Month	Gallons	Acres	Gallons	Acres	Gallons	
April	20.5	20.5	136.7	183.65	0	39.77
May	24.86	24.86	109.84	147.17	0	38.14
June	65.77	67.44	92.3	124.37	0	48.01
July	464.12	471.12	47.45	66.17	0	154.78
August	577.57	585.09	36.03	49.15	0	181.91
September	572.31	579.21	53.38	72.88	0	178
October	323.05	328.32	36.85	49.75	0	103.29
November	14.25	14.92	4.28	5.92	0	7.03
Total	2062.43	2091.46	516.83	699.06	0	750.93

2005	2,4 - D		Glyphosate		R-11	Agri-dex
Month	Gallons	Acres	Gallons	Acres	Gallons	
April	26.5	26.5	49.3	65.44	0	24.8
May	17.25	17.25	44.5	59.23	0	23
June	68	68	62.13	82.69	0	50.13
July	549.16	553.56	0.76	0.97	0	188.16
August	600.93	604.93	44.15	58.82	0	229.04
September	401.03	403.03	17.6	23.41	0	143.99
October	240.5	243.83	0.1	0.13	0	77.1
November	0	0	0	0	0	0
Total	1903.37	1917.1	218.54	290.69	0	736.22

Table 3: WHCP Treatment Sites

County	Location	Site Number(s)	Water Type
San Joaquin	San Joaquin River	1,2,3,4,5,	Tidal
San Joaquin	French Camp Slouogh, Walker Slough	6	Tidal
San Joaquin	San Joaquin River	7	Tidal
San Joaquin	Mormon Slough, San Joaquin River Deep Water Ship Channel	8	Tidal
San Joaquin	Burns Cutoff	9	Tidal
San Joaquin	Buckley Cove, San Joaquin River Deep Water Ship Channel	10	Tidal
San Joaquin	Black Slough, Black Slough Landing, 14 Mile Slough, San Joaquin River	11	Tidal
San Joaquin	Turner Cut	12	Tidal
San Joaquin	Heypress Reach, Hog Island Cut, San Joaquin River Deep Water Ship Channel, 21 Mile Slough	13	Tidal
San Joaquin	San Joaquin River	14	Tidal
San Joaquin	Empire Tract Slough	15	Tidal
San Joaquin	Mandeville Cut, Mandeville Reach, San Joaquin River Deep Water Ship Channel, 3- River Reach, Venice Cut, Venice Reach	16	Tidal
San Joaquin	Potato Slough	17	Tidal
San Joaquin	Mokelumne River	18	Tidal
Contra Costa	San Joaquin River	19	Tidal
Sacramento	San Joaquin River, 7-Mile Cut	20	Tidal
Contra Costa	San Joaquin River	21	Tidal
Sacramento	Sacramento River, 3-Mile Slough	22	Tidal
Sacramento	Lake Natoma	none	Slow Moving
Contra Costa, Sacramento	False River, San Joaquin River	23	Tidal
Contra Costa, Sacramento	San Joaquin River	24	Tidal
San Joaquin	14 Mile Slough	25	Tidal
San Joaquin	14 Mile Slough	26,28,29	Tidal
San Joaquin	5 Mile Slough	27	Tidal
San Joaquin	Mosher Slough	30	Tidal
San Joaquin	Bear Creek, Disappointment Slough, Pixley Slough	31	Tidal
San Joaquin	Disappointment Slough	32,33	Tidal
San Joaquin	Bishop Cut	34	Tidal
San Joaquin	Telephone Cut	35	Tidal
San Joaquin	White Slough	36,37,39	Tidal
San Joaquin	Bishop Cut	38	Tidal
San Joaquin	Little Potato Slough	40,41	Tidal
San Joaquin	Little Connection Slough	42	Tidal
San Joaquin	Potato Slough	43,44	Tidal
San Joaquin	Middle River	45,46,47,48,49,52,53,56,58,59,66,67,68	Tidal
San Joaquin	North Canal, Victoria Canal	50,51	Tidal
San Joaquin	North Victoria Canal, Woodard Canal	54,55	Tidal
San Joaquin	Railroad Cut	57	Tidal
San Joaquin	Empire Cut	60	Tidal

County	Location	Site Number(s)	Water Type
San Joaquin	Whiskey Slough	61,62,63	Tidal
San Joaquin	Trapper Slough	64	Tidal
San Joaquin	Latham Slough	65	Tidal
San Joaquin	Connection Slough, Middle River	69	Tidal
San Joaquin	Old River	70,71	Tidal
San Joaquin	Old River, Paradise Cut	72	Tidal
San Joaquin	Old River, Paradise Cut, Salmon Slough	73	Tidal
San Joaquin	Sugar Cut, Tom Paine Slough	74	Tidal
San Joaquin	Old River	75,76,77,78,79,83,84,85,87,89,90,91,92,98,99	Tidal
San Joaquin	Fabian & Bell Canal, Grant Line Canal	80,81,82	Tidal
Contra Costa	Italian Slough	88	Tidal
Contra Costa	Indian Slough	93	Tidal
Contra Costa	Warner Dredge Cut	94,95,96	Tidal
Contra Costa	Rock Slough	97	Tidal
San Joaquin	Connection Slough, Old River	100	Tidal
San Joaquin	Old River	101	Tidal
Contra Costa	Sheep Slough	102	Tidal
Contra Costa, San Joaquin	Old River	103,104	Tidal
Contra Costa	False River,	105	Tidal
Contra Costa	Fisherman's Cut	106	Tidal
Contra Costa	Piper Slough	107	Tidal
Contra Costa	Roosevelt Cut, Sand Mound Slough	108	Tidal
Contra Costa	Sand Mound Slough	109	Tidal
Contra Costa	Taylor Slough	110,111	Tidal
Contra Costa	Dutch Slough, Emerson Slough	112	Tidal
Contra Costa	Dutch Slough	113, 114	Tidal
Contra Costa	Big Break	115,116,117,118	Tidal
Contra Costa, Sacramento	San Joaquin River	119,120,121	Tidal
Sacramento	Sherman Lake	**132**	Tidal
Contra Costa	Frank's Tract	**173, 174, 175**	Tidal
Solano	Sacramento River, Decker Isalnd	176	Tidal
San Joaquin	South Mokelumne River	200, 201, 202, 204, 206, 208	Tidal
San Joaquin	Sycamore Slough	203	Tidal
San Joaquin	Hog Slough	205	Tidal
San Joaquin	Beaver Slough	207	Tidal
Sacramento, San Joaquin	North Mokelumne River	209, 210,211,2113	Tidal
Sacramento, San Joaquin	Snodgrass Slough, Delta Cross Channel	**212**	To Be Determined
Sacramento	Snodgrass Slough	214, 215, 216,217, 218, 219	Tidal
Sacramento	Stone Lakes	220, 221, 222, 223, 224, 225, 226, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239	Tidal

Table 3: WHCP Treatment Sites

County	Location	Site Number(s)	Water Type
Sacramento, Solano	Sacramento River	**240**	To Be Determined
Sacramento	Sacramento River	**241, 242, 243, 244, 245**	To Be Determined
Sacramento, Yolo	Sacramento River	**246, 247, 248, 249, 250**	To Be Determined
Sacramento, Solano	Steamboat Slough	**251, 252, 253**	To Be Determined
Sacramento	Steamboat Slough	**254, 255**	To Be Determined
Sacramento, Solano	Sutter Slough	**256, 257**	To Be Determined
Sacramento	Sutter Slough	**258,259**	To Be Determined
Soalno, Sacramento	Cache Slough	**260**	To Be Determined
Solano	Cache Slough	**261, 272, 277, 278, 280**	To Be Determined
Solano	Miner Slough	**262, 263,264, 265, 266**	To Be Determined
Solano	Prospect Lsough	**267**	To Be Determined
Solano, Yolo	Sacramento Deep Water Ship Channel	**268**	To Be Determined
Solano	Tox Drain, Liberty	**270**	To Be Determined
Solano, Yolo	Tox Drain, Liberty	**271**	To Be Determined
Solano	Shag Slough	**273, 274**	To Be Determined
Solano, Yolo	Shag Slough	**275, 276**	To Be Determined
Solano	Hass Slough, Duck Slough	**279**	To Be Determined
Solano	Lindsey Slough	**281, 282, 283, 284**	To Be Determined
Sacramento	Georgiana Slough	**285, 286, 287, 288, 289**	To Be Determined
San Joaquin	San Joaquin River	300, 302, 303, 304, 305, 306, 307, 308, 309	Fast or Slow Moving
San Joaquin	Wethall Slough	301	Fast or Slow Moving
Stanislaus	San Joaquin River	310, 313, 314, 316, 318, 319, 320, 321, 322, 323	Fast or Slow Moving
Stanislaus	Brush Lake	316	Fast or Slow Moving
Stanislaus	Finnegan Cut, San Joaquin River	311, 312	Fast or Slow Moving
Stanislaus	Laird Slough	315	Fast or Slow Moving
Stanislaus	Del Puerto Creek, San Joaquin River	317	Fast or Slow Moving
Stanislaus	Lake Ramona	320	Fast or Slow Moving
Merced, Stanislaus	San Joaquin River	324, 325	Fast or Slow Moving

Table 3: WHCP Treatment Sites

County	Location	Site Number(s)	Water Type
Merced	San Joaquin River	401, 403, 414, 415, 417, 418, 419, 421,422, 423, 424, 425, 426, 427	Fast or Slow Moving
Merced	Snag Slough, San Joaquin River	402	Fast or Slow Moving
Merced	Salt Slough	405, 406, 407, 408, 409, 410, 412, 413	Fast or Slow Moving
Merced	Poso Slough	414A	Fast or Slow Moving
Merced	Mud Slough	411	Fast or Slow Moving
Merced	Bear Creek, Bravel Slough	416	Fast or Slow Moving
Merced	San Joaquin River	**420**	To Be Determined
Merced	Merced River	500, 501, 502, 503, 504, 505, 506, 507, 508, 509, 510, 511, 512, 513, 514, 515, 517, 518, 519, 520, 521, 522, 523, 524, 526, 527, 530, 532	Fast or Slow Moving
Merced	Ingalsbe Slough, Hope Town Slough	516	Fast or Slow Moving
Merced	Ingalsbe Slough	525	Fast or Slow Moving
Merced	Merced River, North Canal	528, 529	Fast or Slow Moving
Merced	Main Canal	531, 533, 537	Fast or Slow Moving
Merced	Main Canal, Canal Creek	534, 535	Fast or Slow Moving
Merced	Main Canal, Parkinson Creek	536	Fast or Slow Moving
Stanislaus	Stanislaus River	600	Fast or Slow Moving
Stanislaus	Toulumne River	700, 701, 702, 703, 704, 705, 706, 707, 708, 709, 710, 711, 712, 713, 714, 715, 716, 717, 718	Fast or Slow Moving
Fresno	San Joaquin River	900, 901, 902, 903, 904, 905, 909, 911, 912, 913, 914, 915, 916, 917, 918, 919, 920, 921, 922, 923, 924, 925, 926, 927, 928, 929	Fast or Slow Moving
Fresno, Madera	Firebaugh	**906, 907, 908**	To Be Determined
Fresno	San Joaquin River, Mendota Pool	910	Fast or Slow Moving
Fresno	Fresno Slough	910A, 910B	Fast or Slow Moving

Table 3: WHCP Treatment Sites
Bold Numbers are new treatment sites as of 2003.

Table 6:

Monthly Occurrences of Dissolved Oxygen Depressions below the 5mg/L Criteria in the Stockton Deepwater Ship Channel (Rough and Ready Island DO monitoring site) Water Years 2000 to 2004

			Water Year			
Month	**2000-01**	**2001-02**	**2002-03**	**2003-04**	**2004-05**	**Monthly Sum**
September	0	26**	30**	16**	30**	102
October	0	0	7	0	4	11
November	0	0	12	0	3	15
December	6	4*	13	2	13	38
January	3	4	19	7	0	33
February	0	25	28	13	0	66
March	0	7	9	0	0	16
April	0	4	4	0	0	8
May	2*	0	2	4	0	8
Yearly Sum	11	70	124	42	50	**Total=297**

* = Suspect Data – potentially faulty DO meter readings

** = Wind driven and photosynthetic daily variations in DO level; very low night-time DO levels, high late afternoon levels

Table 7. Salmon and Steelhead monitoring programs in the Sacramento - San Joaquin River basins, and Suisun Marsh.

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
Central Valley	***Chinook salmon, Steelhead***	Sacramento River	Scale and otolith collection	Coleman National Hatchery, Sacramento River and tributaries	Scale and otolith microstructure analysis	Year-round	CDFG
		Sacramento River and San Joaquin River	Central Valley angler survey	Sacramento and San Joaquin rivers and tributaries downstream to Carquinez	In-river harvest	8 or 9 times per month, year-round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at Balls Ferry and Deschutes Road Bridge	Juvenile emigration timing and abundance	Year round	CDFG
		Sacramento River	Rotary screw trap	Upper Sacramento River at RBDD	Juvenile emigration timing and abundance	Year round	FWS
		Sacramento River	Ladder counts	Upper Sacramento River at RBDD	Escapement estimates, population size	Variable, May - Jul	FWS
		Sacramento River	Beach seining	Sacramento River, Caldwell Park to Delta	Spatial and temporal distribution	Bi-weekly or monthly, year-round	FWS
		Sacramento River	Beach seining, snorkel survey, habitat mapping	Upper Sacramento River from Battle Creek to Caldwell Park	Evaluate rearing habitat	Random, year-round	CDFG
		Sacramento River	Rotary screw trap	Lower Sacramento River at Knight's Landing	Juvenile emigration and post-spawner adult steelhead migration	Year-round	CDFG
		Sacramento-San Joaquin basin	Kodiak/Midwater trawling	Sacramento River at Sacramento, Chipps Island, San Joaquin River at Mossdale	Juvenile outmigration	Variable, year-round	FWS
		Sacramento-San Joaquin Delta	Kodiak trawling	Various locations in the Delta	Presence and movement of juvenile salmonids	Daily, Apr - Jun	IEP
		Sacramento-San Joaquin Delta	Kodiak trawling	Jersey Point	Mark and recapture studies on juvenile salmonids	Daily, Apr - Jun	Hanson Environmental Consultants
Central Valley	***Chinook salmon, Steelhead, Continued***	Sacramento-San Joaquin Delta	Salvage sampling	CVP and SWP south Delta pumps	Estimate salvage and loss of juvenile salmonids	Daily	USBR/CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Battle Creek	Rotary screw trap	Above and below Coleman Hatchery barrier	Juvenile emigration	Daily, year-round	FWS
		Battle Creek	Weir trap, carcass counts, snorkel/ kayak survey	Battle Creek	Escapement, migration patterns, demographics	Variable, year-round	FWS
		Clear Creek	Rotary screw trap	Lower Clear Creek	Juvenile emigration	Daily, mid Dec- Jun	FWS
		Feather River	Rotary screw trap, Beach seining, Snorkel survey	Feather River	Juvenile emigration and rearing, population estimates	Daily, Dec - Jun	DWR
		Yuba River	Rotary screw trap	lower Yuba River	Life history evaluation, juvenile abundance, timing of emergence and migration, health index	Daily, Oct - Jun	CDFG
		Feather River	Ladder at hatchery	FRH	Survival and spawning success of hatchery fish (spring-run Chinook salmon), determine wild vs. hatchery adults (steelhead)	Variable, Apr - Jun	DWR, CDFG
		Mokelumne River	Habitat typing	Lower Mokelumne River between Camanche Dam and Cosumnes River confluence	Habitat use evaluation as part of limiting factors analysis	Various, when river conditions allow	EBMUD
		Mokelumne River	Redd surveys	Lower Mokelumne River between Camanche Dam and Hwy 26 bridge	Escapement estimate	Twice monthly, Oct 1- Jan 1	EBMUD
		Mokelumne River	Rotary screw trap, mark/recapture	Mokelumne River, below Woodbridge Dam	Juvenile emigration and survival	Daily, Dec- Jul	EBMUD
		Mokelumne River	Angler survey	Lower Mokelumne River below Camanche Dam to Lake Lodi	In-river harvest rates	Various, year-round	EBMUD
<u>Central Valley</u>	***Chinook salmon, Steelhead, Continued***	Mokelumne River	Beach seining, electrofishing	Lower Mokelumne	Distribution and habitat use	Various locations at various times throughout the year	EBMUD
		Mokelumne River	Video monitoring	Woodbridge Dam	Adult migration timing, population estimates	Daily, Aug - Mar	EBMUD

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Calaveras River	Adult weir, snorkel survey, electrofishing	Lower Calaveras River	Population estimate, migration timing, emigration timing	Variable, year-round	Fishery Foundation
		Stanislaus River	Rotary screw trap	lower Stanislaus River at Oakdale and Caswell State Park	Juvenile outmigration	Daily, Jan - Jun, dependent on flow	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel surveys, hook and line survey, beach seining, electrofishing	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence and distribution, habitat use, and abundance	Variable, Mar- Jul	CDFG
	Central Valley Steelhead	Sacramento River	Angler Survey	RBDD to Redding	In-river harvest	Random Days, Jul 15 - Mar 15	CDFG
		Battle Creek	Hatchery counts	CNFH	Returns to hatchery	Daily, Jul 1 - Mar 31	FWS
		Clear Creek	Snorkel survey, redd counts	Clear Creek	Juvenile and spawning adult habitat use	Variable, dependent on river conditions	FWS
		Mill Creek, Antelope Creek, Beegum Creek	Spawning survey - snorkel and foot	Upper Mill, Antelope, and Beegum Creeks	Spawning habitat availability and use	Random days when conditions allow, Feb - Apr	CDFG
		Mill Creek, Deer Creek, Antelope Creek	Physical habitat survey	Upper Mill, Deer, and Antelope Creeks	Physical habitat conditions	Variable	USFS
		Dry Creek	Rotary screw trap	Miner and Secret Ravine’s confluence	Downstream movement of emigrating juveniles and post-spawner adults	Daily, Nov- Apr	CDFG
		Dry Creek	Habitat survey, snorkel survey, PIT tagging study	Dry Creek, Miner and Secret Ravine’s	Habitat availability and use	Variable	CDFG
Central Valley	***Central Valley Steelhead Continued***	Battle Creek	Otolith analysis	CNFH	Determine anadromy or freshwater residency of fish returning to hatchery	Variable, dependent on return timing	FWS
		Feather River	Hatchery coded wire tagging	FRH	Return rate, straying rate, and survival	Daily, Jul - Apr	DWR

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Feather River	Snorkel survey	Feather River	Escapement estimates	Monthly, Mar to Aug (upper river), once annually (entire river)	DWR
		Yuba River	Adult trap	lower Yuba River	Life history, run composition, origin, age determination	Year-round	Jones and Stokes
		American River	Rotary screw trap	Lower American River, Watt Ave. Bridge	Juvenile emigration	Daily, Oct- Jun	CDFG
		American River	Beach seine, snorkel survey, electrofishing	American River, Nimbus Dam to Paradise Beach	Emergence timing, juvenile habitat use, population estimates	Variable	CDFG
		American River	Redd surveys	American River, Nimbus Dam to Paradise Beach	Escapement estimates	Once, Feb - Mar	CDFG, BOR
		Mokelumne River	Electrofishing, gastric lavage	Lower Mokelumne River	Diet analysis as part of limiting factor analysis	Variable	EBMUD
		Mokelumne River	Electrofishing, hatchery returns	Lower Mokelumne River, Mokelumne River hatchery	O. Mykiss genetic analysis to compare hatchery returning steelhead to residents	Variable	EBMUD
		Calaveras River	Rotary screw trap, pit tagging, beach seining, electrofishing	lower Calaveras River	Population estimate, migration patterns, life history	Variable, year-round	S.P. Cramer
		San Joaquin River basin	Fyke nets, snorkel survey, hook and line survey, beach seining, electrofishing, fish traps/weirs	Stanislaus, Tuolumne, Merced, and mainstem San Joaquin rivers	Presence, origin, distribution, habitat use, migration timing, and abundance	Variable, Jun - Apr	CDFG
		Merced River	Rotary screw trap	Lower Merced River	Juvenile oumigration	Variable, Jan-Jun	Natural Resource Scientists, Inc.
Central Valley	***Central Valley Steelhead Continued***	Central Valley-wide	Carcass survey, hook and line survey, electrofishing, traps, nets	Upper Sacramento, Yuba, Mokelumne, Calaveras, Tuolumne, Feather, Cosumnes, and Stanislaus Rivers, and Mill, Deer, Battle, and Clear Creeks	Occurrence and distribution of *O. Mykiss*	Variable, year-round	CDFG

Geographic Region	Species	Watershed	Methods	Geographic Area Covered	Monitoring Parameters	Monitoring Period	Implementing Agency
		Central Valley - wide	Scale and otolith sampling	Coleman NFH, Feather, Nimbus, Mokelumne River hatcheries	Stock identification, juvenile residence time, adult age structure, hatchery contribution	Variable upon availability	CDFG
		Central Valley - wide	Hatchery marking	All Central Valley Hatcheries	Hatchery contribution	Variable	FWS, CDFG
	Sacramento River Winter-run Chinook salmon	Sacramento River	Aerial redd counts	Keswick Dam to Princeton	Number and proportion of reds above and below RBDD	Weekly, May 1- July 15	CDFG
		Sacramento River	Carcass survey	Keswick Dam to RBDD	In-river spawning escapement	Weekly, Apr 15- Aug 15	FWS, CDFG
		Battle Creek	Hatchery marking	Colemen National Fish Hatchery	Hatchery contribution	Variable	FWS, CDFG
		Sacramento River	Ladder counts	RBDD	Run-size above RBDD	Daily, Mar 30- Jun 30	FWS
		Pacific Ocean	Ocean Harvest	California ports south of Point Arena	Ocean landings	May 1- Sept 30 (commercial), Feb 15 - Nov 15 (sport)	CDFG
	Central Valley Spring-run Chinook salmon	Mill, Deer, Antelope, Cottonwood, Butte, Big Chico Creeks	Rotary screw trap, snorkel survey, electrofishing, beach seining	upper Mill, Deer, Antelope, Cottonwood, Butte, and Big Chico creeks	Life history assessment, presence, adult escapement estimates	Variable, year-round	CDFG
		Feather River	Fyke trapping, angling, radio tagging	Feather River	Adult migration and holding behavior	Variable, Apr-June	DWR
		Yuba River	Fish trap	lower Yuba River, Daguerre Point Dam	Timing and duration of migration, population estimate	Daily, Jan - Dec	CDFG
Suisun Marsh	***Chinook salmon***	Suisun Marsh	Otter trawling, beach seining	Suisun Marsh	Relative population estimates and habitat use	Monthly, year-round	UC Davis
		Suisun Marsh	Gill netting	Suisun Marsh Salinity Control Gates	Fish passage	Variable, Jun - Dec	CDFG

Appendix B: Figures

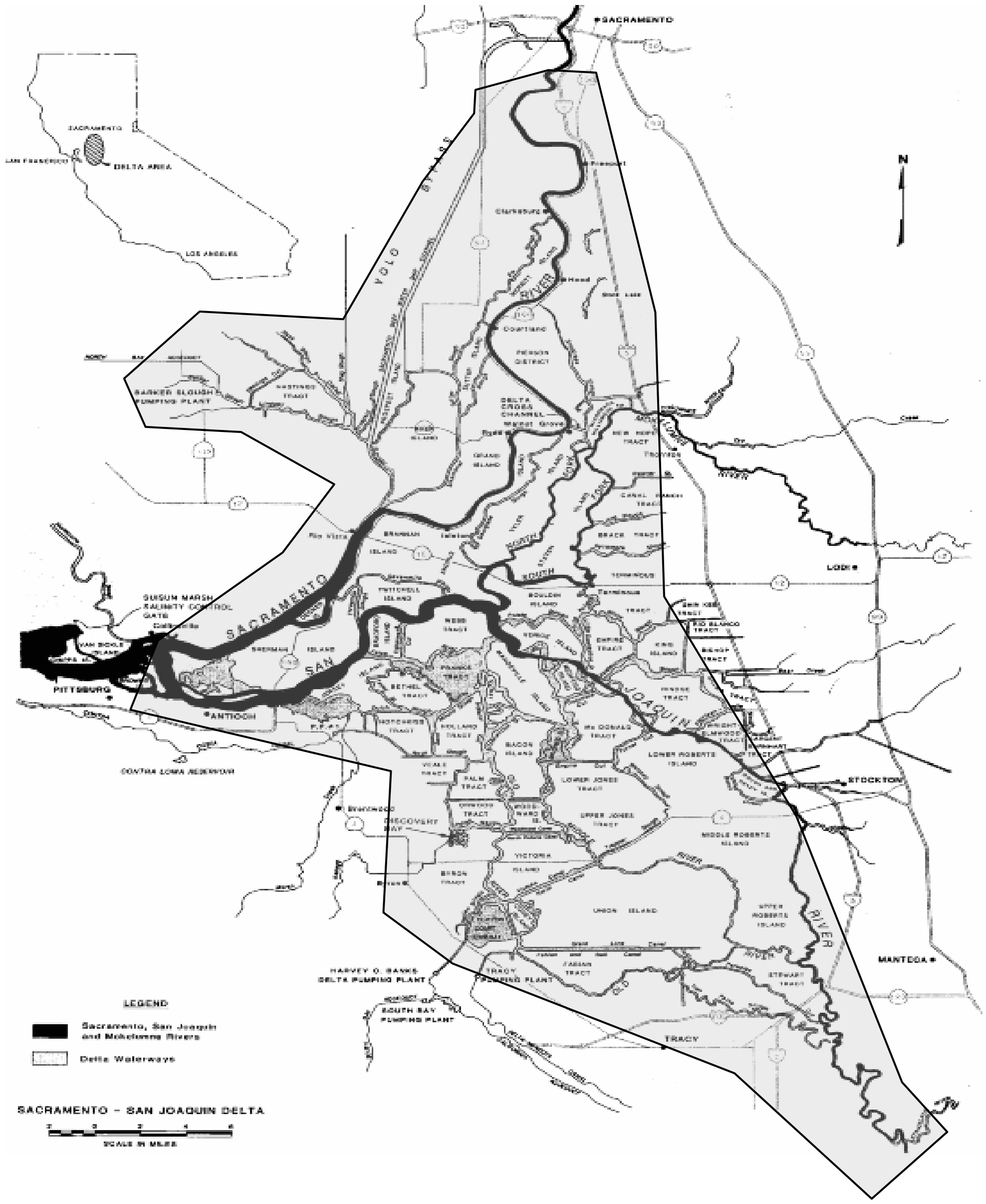
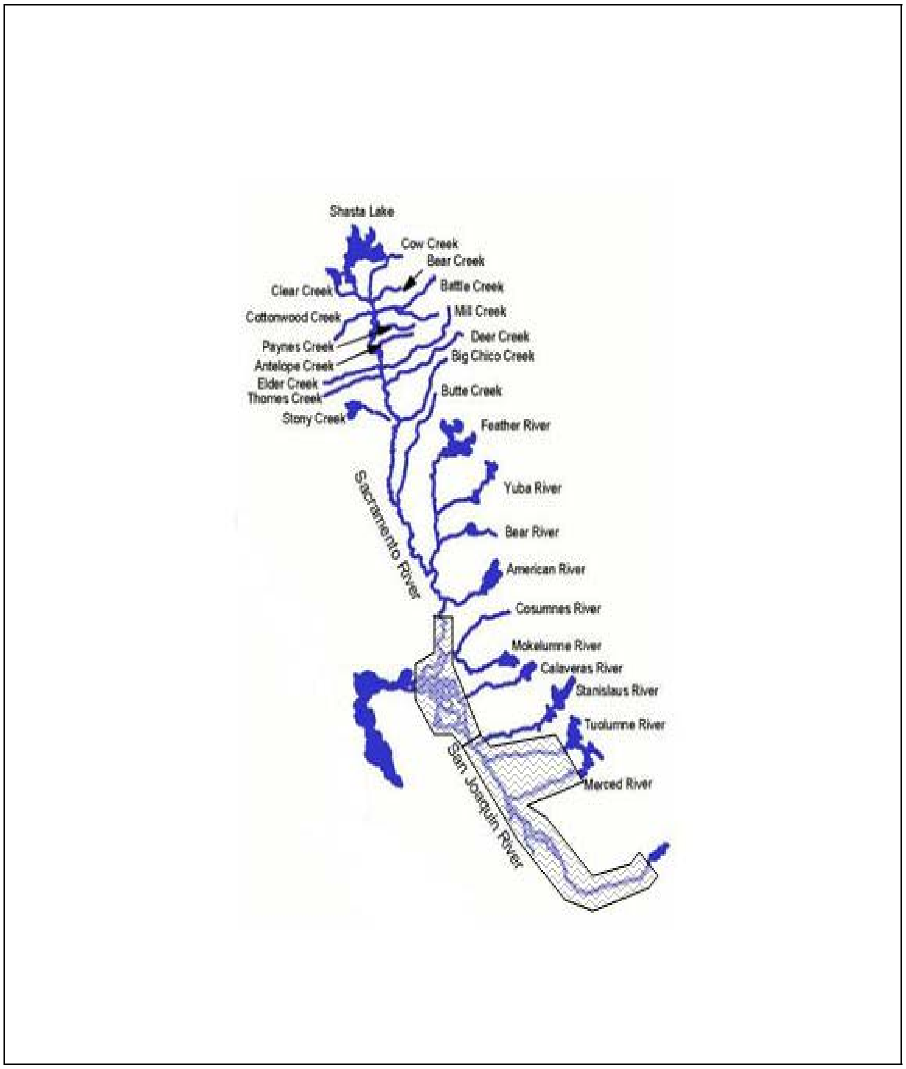


Figure 1A: Generalized Water Hyacinth Treatment Boundaries in the Legal Delta. Treatment boundaries are not to exact geographic locale.

Figure 1b: Generalized Water Hyacinth Boundaries in the San Joaquin Valley



Shaded areas indicate generalized areas of herbicide applications for the WHCP.

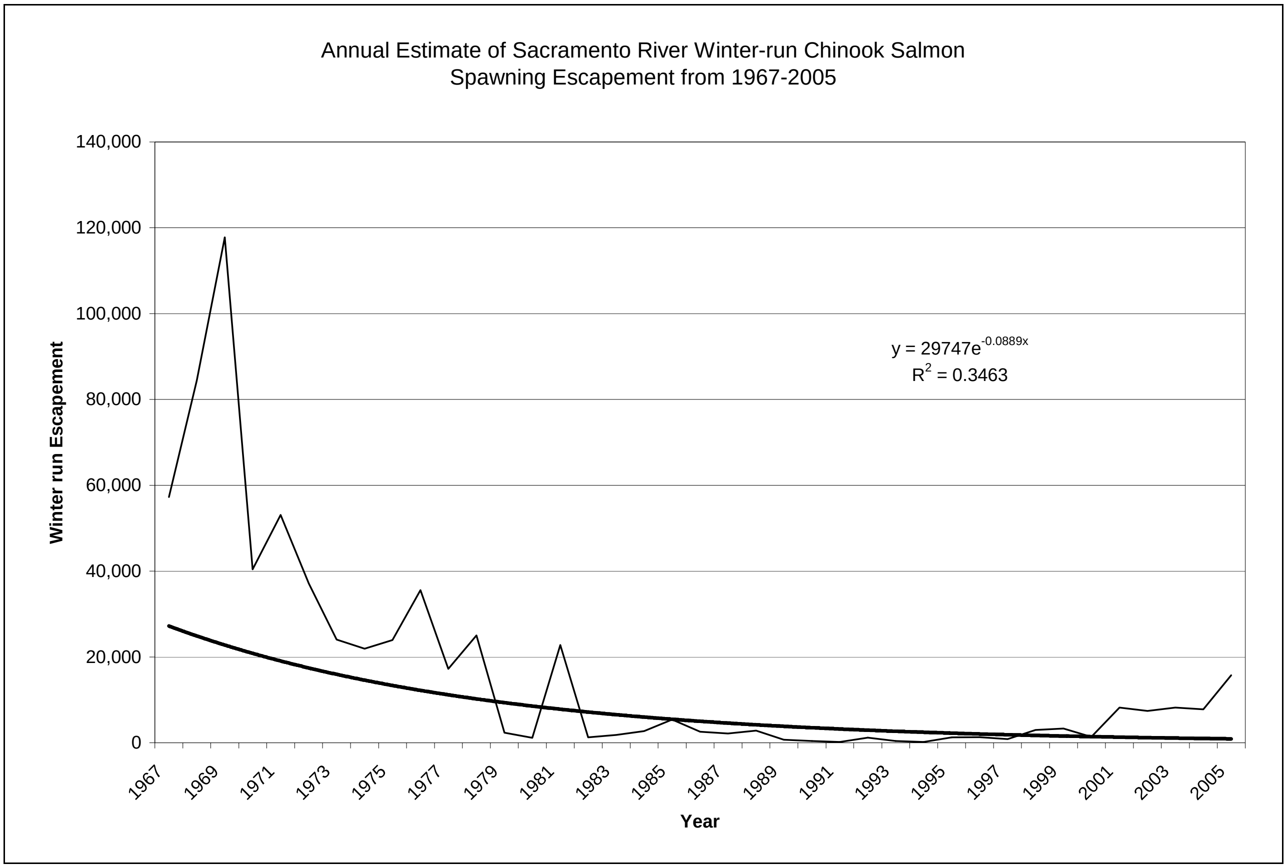


Figure 2:
Annual estimated Sacramento River winter-run Chinook salmon escapement population.
Sources: PFMC 2002, DFG 2004a, NMFS 1997
Trendline for figure 2 is an exponential function: $Y=29{,}747e^{-0.0889x}$, $R^2=0.3463$.

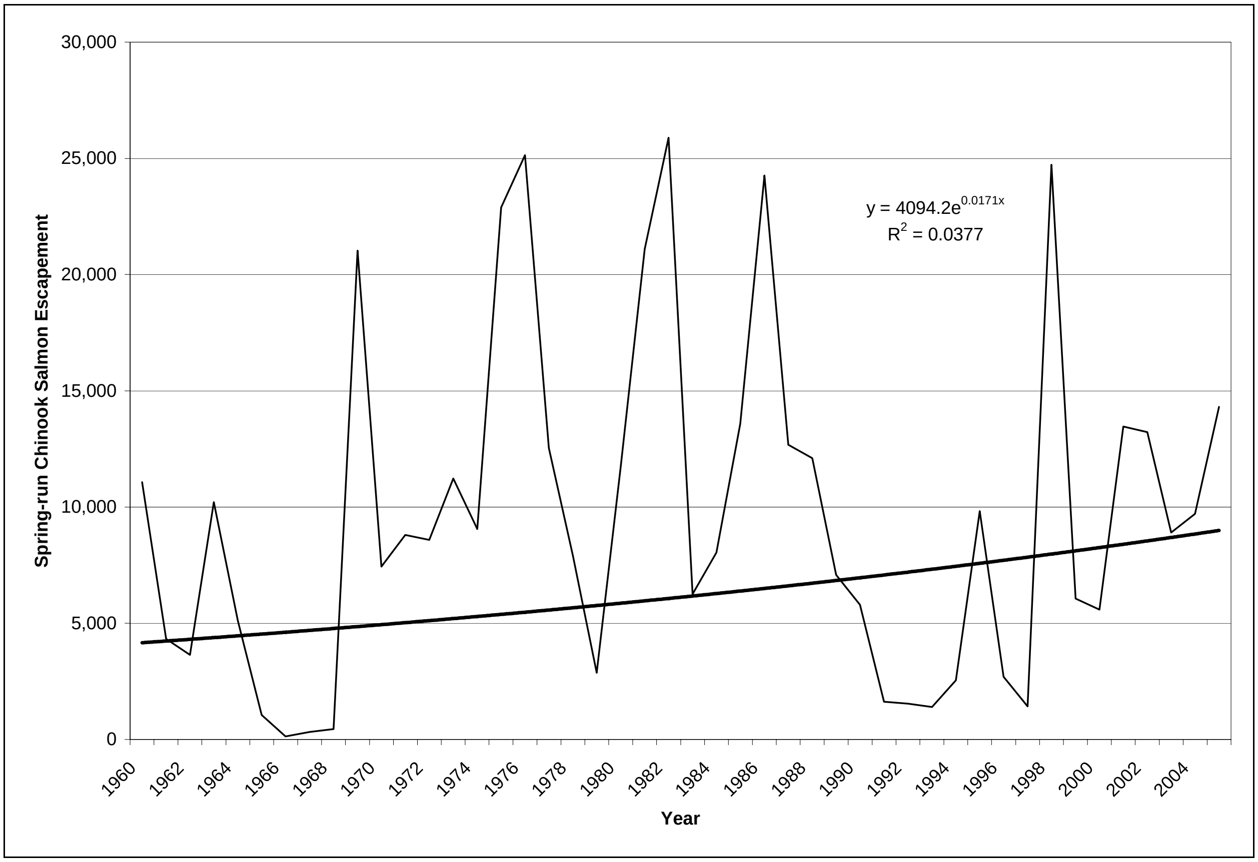
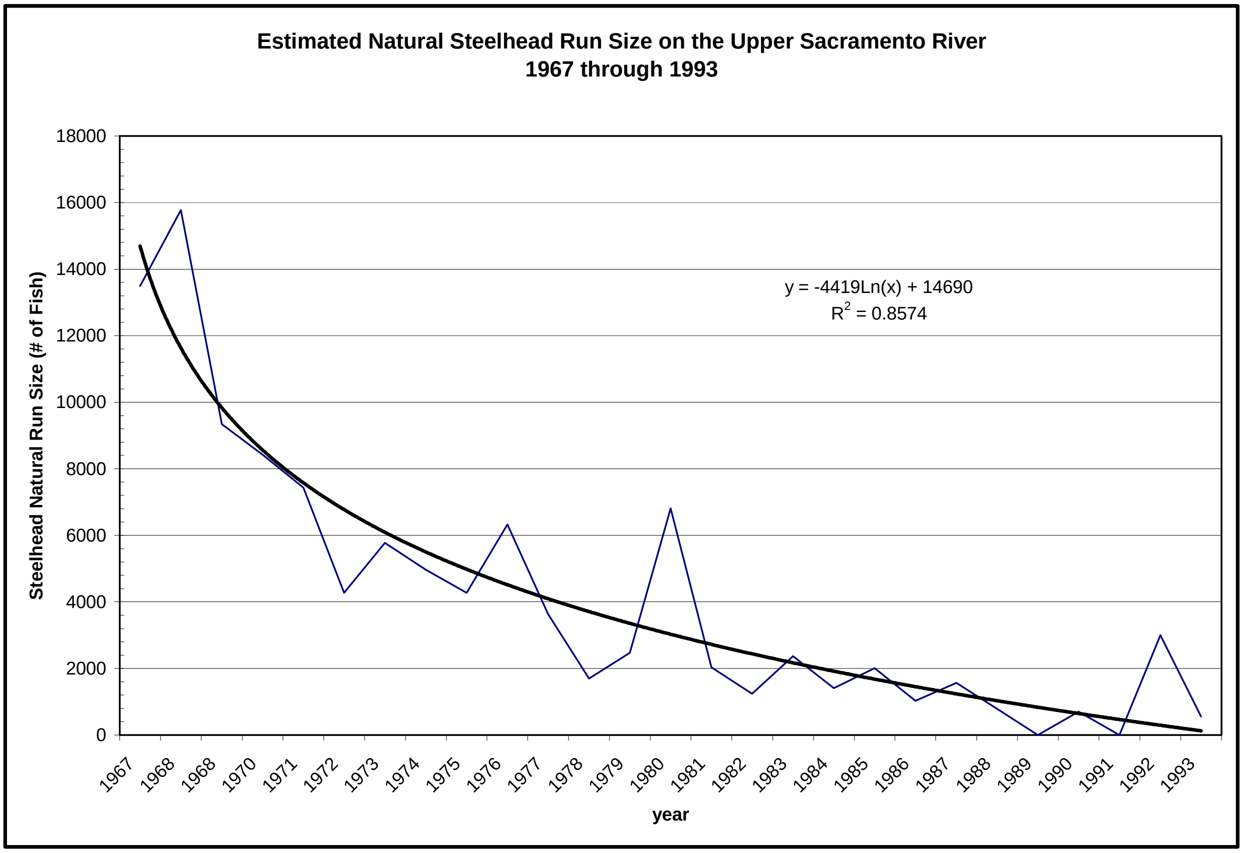


Figure 3:
Annual estimated Central Valley spring-run Chinook salmon escapement population for the Sacramento River watershed for years 1967 through 2003.
Sources: PFMC 2002, DFG 2004b, Yoshiyama 1998.
Trendline for figure 3 is an exponential function: Y= 4094.2 $e^{0.0171}$, $R^2 = 0.0377$.



Note: Steelhead escapement surveys at RBDD ended in 1993

Figure 4:
Estimated Central Valley natural steelhead escapement population in the upper Sacramento River based on RBDD counts.
Source: McEwan and Jackson 1996.
Trendline for Figure 4 is a logarithmic function: $Y= -4419 \ln(x) + 14690$ $R^2= 0.8574$

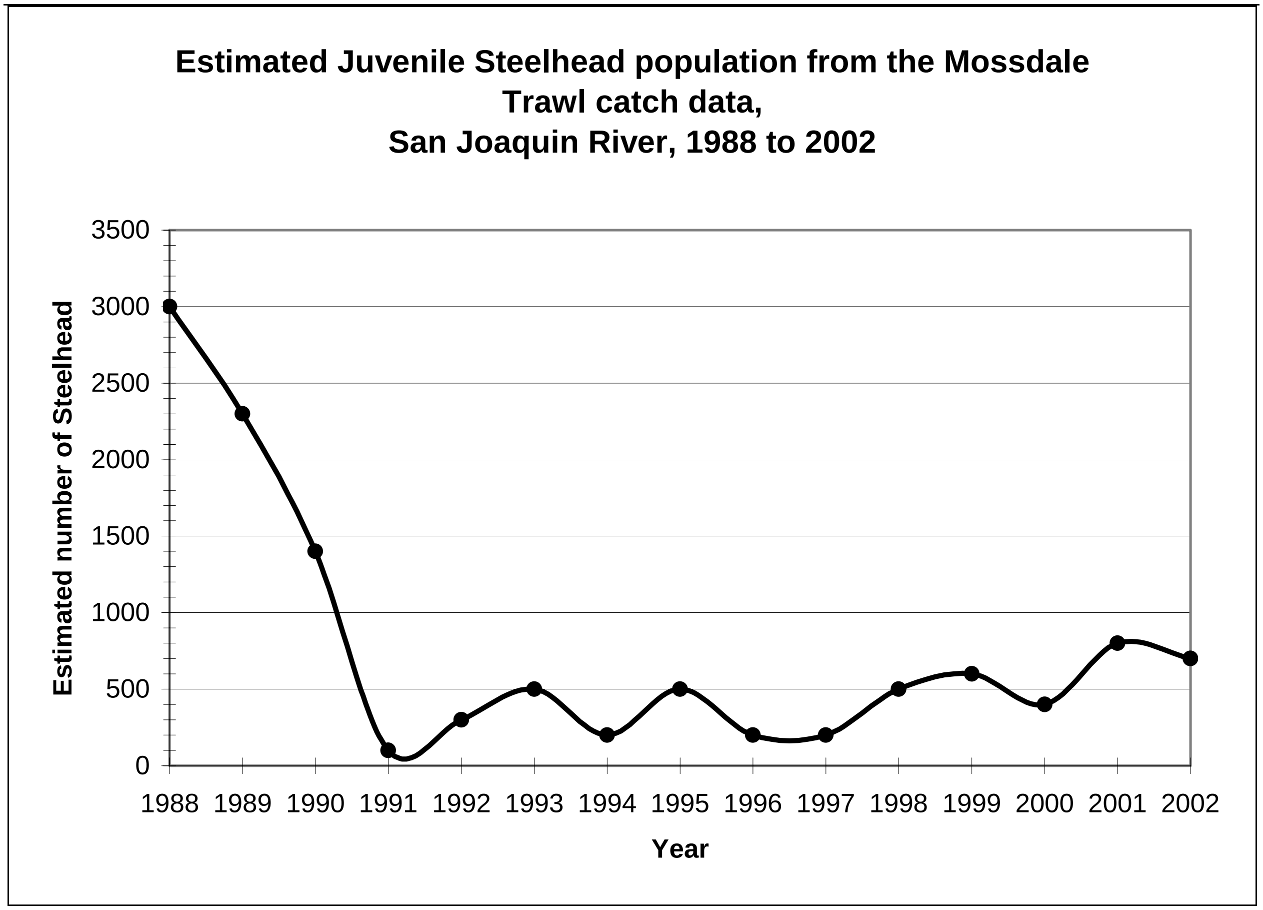


Figure 5:
Estimated number of juvenile Central Valley steelhead derived from the Mossdale trawl surveys on the San Joaquin River from 1988 to 2002.
Source: Marston (DFG), 2003.

Enclosure 2

Magnuson-Stevens Fishery Conservation and Management Act

ESSENTIAL FISH HABITAT CONSERVATION RECOMMENDATIONS

I. IDENTIFICATION OF ESSENTIAL FISH HABITAT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended (U.S.C. 180 *et seq.*), requires that Essential Fish Habitat (EFH) be identified and described in Federal fishery management plans (FMPs). Federal action agencies must consult with NOAA's National Marine Fisheries Service (NMFS) on any activity which they fund, permit, or carry out that may adversely affect EFH. NMFS is required to provide EFH conservation and enhancement recommendations to the Federal action agencies.

EFH is defined as those waters and substrates necessary to fish for spawning, breeding, feeding, or growth to maturity. For the purposes of interpreting the definition of EFH, "waters" includes aquatic areas and their associated physical, chemical, and biological properties that are used by fish, and may include areas historically used by fish where appropriate; "substrate" includes sediment, hard bottom, structures underlying the waters, and associated biological communities; "necessary" means habitat required to support a sustainable fishery and a healthy ecosystem; and, "spawning, breeding, feeding, or growth to maturity" covers all habitat types used by a species throughout its life cycle. The proposed project site is within the region identified as EFH for Pacific salmon in Amendment 14 of the Pacific Salmon FMP and for starry flounder (*Platichthys stellatus*) and English sole (*Parophrys vetulus*) in Amendment 11 to the Pacific Coast Groundfish FMP.

The Pacific Fishery Management Council (PFMC) has identified and described EFH, Adverse Impacts and Recommended Conservation Measures for salmon in Amendment 14 to the Pacific Coast Salmon FMP (PFMC 1999). Freshwater EFH for Pacific salmon in the California Central Valley includes waters currently or historically accessible to salmon within the Central Valley ecosystem as described in Myers *et al.* (1998), and includes the San Joaquin Delta (Delta) hydrologic unit (*i.e.*, number 18040003), Suisun Bay hydrologic unit (18050001) and the Lower Sacramento hydrologic unit (18020109). Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), and Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*) are species managed under the Salmon Plan that occur in the Delta, Suisun Bay, and Lower Sacramento units.

Factors limiting salmon populations in the Delta include periodic reversed flows due to high water exports (drawing juveniles into large diversion pumps), loss of fish into unscreened agricultural diversions, predation by introduced species, and reduction in the quality and quantity of rearing habitat due to channelization, pollution, riprapping, *etc*. (Dettman *et al.* 1987;

California Advisory Committee on Salmon and Steelhead Trout 1988, Kondolf *et al.* 1996a, 1996b). Factors affecting salmon populations in Suisun Bay include heavy industrialization within its watershed and discharge of wastewater effluents into the bay. Loss of vital wetland habitat along the fringes of the bay reduce rearing habitat and diminish the functional processes that wetlands provide for the bay ecosystem.

A. Life History and Habitat Requirements

1. Pacific Salmon

General life history information for Central Valley Chinook salmon is summarized below. Information on Sacramento River winter-run and Central Valley spring-run Chinook salmon life histories is summarized in the preceding biological opinion for the proposed project (Enclosure 1). Further detailed information on Chinook salmon Evolutionarily Significant Units (ESU) are available in the NMFS status review of Chinook salmon from Washington, Idaho, Oregon, and California (Myers *et al.* 1998), and the NMFS proposed rule for listing several ESU of Chinook salmon (63 FR 11482).

Adult Central Valley fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from July through December and spawn from October through December while adult Central Valley late fall-run Chinook salmon enter the Sacramento and San Joaquin Rivers from October to April and spawn from January to April (U.S. Fish and Wildlife Service [FWS] 1998). Chinook salmon spawning generally occurs in clean loose gravel in swift, relatively shallow riffles or along the edges of fast runs (NMFS 1997).

Egg incubation occurs from October through March (Reynolds *et al.* 1993). Shortly after emergence from their gravel nests, most fry disperse downstream towards the Delta and into the San Francisco Bay and its estuarine waters (Kjelson *et al.* 1982). The remaining fry hide in the gravel or station in calm, shallow waters with bank cover such as tree roots, logs, and submerged or overhead vegetation. These juveniles feed and grow from January through mid-May, and emigrate to the Delta and estuary from mid-March through mid-June (Lister and Genoe 1970). As they grow, the juveniles associate with coarser substrates along the stream margin or farther from shore (Healey 1991). Along the emigration route, submerged and overhead cover in the form of rocks, aquatic and riparian vegetation, logs, and undercut banks provide habitat for food organisms, shade, and protect juveniles and smolts from predation. These smolts generally spend a very short time in the Delta and estuary before entry into the ocean. Whether entering the Delta or estuary as fry or juveniles, Central Valley Chinook salmon depend on passage through the Delta for access to the ocean.

2. Starry Flounder

The starry flounder is a flatfish found throughout the eastern Pacific Ocean, from the Santa Ynez River in California to the Bering and Chukchi Seas in Alaska, and eastwards to Bathurst inlet in Arctic Canada. Adults are found in marine waters to a depth of 375 meters. Spawning takes place during the fall and winter months in marine to polyhaline waters. The adults spawn in shallow coastal waters near river mouths and sloughs, and the juveniles are found almost exclusively in estuaries. The juveniles often migrate up freshwater rivers, but are estuarine dependent. Eggs are broadcast spawned and the buoyant eggs drift with wind and tidal currents. Juveniles gradually settle to the bottom after undergoing metamorphosis from a pelagic larva to a demersal juvenile by the end of April. Juveniles feed mainly on small crustaceans, barnacle larvae, cladocerans, clams and dipteran larvae. Juveniles are extremely dependent on the condition of the estuary for their health. Polluted estuaries and wetlands decrease the survival rate for juvenile starry flounder. Juvenile starry flounder also have a tendency to accumulate many of the anthropogenic contaminants found in the environment.

3. <u>English Sole</u>

The English sole is a flatfish found from Mexico to Alaska. It is the most abundant flatfish in Puget Sound, Washington and is abundant in the San Francisco Bay estuary system. Adults are found in nearshore environments. English sole generally spawn during late fall to early spring at depths of 50 to 70 meters over soft mud bottoms. Eggs are initially buoyant, then begin to sink just prior to hatching. Incubation may last only a couple of days to a week depending on temperature. Newly hatched larvae are bilaterally symmetrical and float near the surface. Wind and tidal currents carry the larvae into bays and estuaries where the larvae undergo metamorphosis into the demersal juvenile. The young depend heavily on the intertidal areas, estuaries, and shallow near-shore waters for food and shelter. Juvenile English sole primarily feed on small crustaceans (*i.e.* copepods and amphipods) and on polychaete worms in these rearing areas. Polluted estuaries and wetlands decrease the survival rate for juvenile English soles. The juveniles also have a tendency to accumulate many of the contaminants found in their environment and this exposure manifests itself as tumors, sores, and reproductive failures.

II. PROPOSED ACTION

The proposed action is described in section II (*Description of the Proposed Action*) of the preceding biological opinion for endangered Sacramento River winter-run Chinook salmon, threatened Central Valley spring-run Chinook salmon, and Central Valley steelhead (*O. mykiss*), the proposed threatened southern population of North American green sturgeon, and critical habitat for winter-run Chinook salmon, spring-run Chinook salmon, and Central Valley steelhead (Enclosure 1).

III. EFFECTS OF THE PROJECT ACTION

The effects of the proposed action on salmonid habitat (*i.e.,* for winter, spring and fall/late fall-run Chinook salmon) are described at length in section V (*Effects of the Action*) of the preceding biological opinion, and generally are expected to apply to Pacific salmon EFH. The general contaminant effects on the quality of EFH for the two species of flatfish are expected to be similar to those for green sturgeon due to their benthic life history. Benthic dwelling flatfish will have direct contact with contaminated sediment and will ingest sediment as well as benthic invertebrates during their foraging activities. Both the starry flounder and the English sole will spend more time as juveniles rearing in the action area than the Chinook salmon smolts. Therefore, these fish species will have a greater duration of exposure to the contaminants of concern than the juvenile Chinook salmon, leading to greater levels of adverse effects to the individual organisms.

IV. CONCLUSION

Based on the best available information, NMFS believes that the proposed Water Hyacinth Control Program may adversely affect EFH for Pacific salmon and groundfish during its five year term of operations (2006 to 2010).

V. EFH CONSERVATION RECOMMENDATIONS

NMFS recommends that the reasonable and prudent measures 1, 2, and 3 from the biological opinion, with their associated terms and conditions, be adopted as EFH Conservation Recommendations for EFH in the action area. In addition, certain other conservation measures need to be implemented in the project area, as addressed in Appendix A of Amendment 14 to the Pacific Coast Salmon Plan (PFMC 1999). NMFS anticipates that implementing those conservation measures intended to minimize disturbance and sediment and pollutant inputs to waterways would benefit groundfish as well.

Riparian Habitat Management–In order to prevent adverse effects to riparian corridors, the U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) should:

- Maintain riparian management zones of appropriate width in the San Joaquin River system and Delta that influence EFH;
- Reduce erosion and runoff into waterways within the project area; and
- Minimize the use of chemical treatments within the riparian management zone to manage nuisance vegetation along the levee banks and reclamation district's irrigation drain.

Bank Stabilization–The installation of riprap or other streambank stabilization devices can reduce or eliminate the development of side channels, functioning riparian and floodplain areas and off channel sloughs. In order to minimize these impacts, the USDA-ARS should:

- Use vegetative methods of bank erosion control whenever feasible. Hard bank protection should be a last resort when all other options have been explored and deemed unacceptable;
- Determine the cumulative effects of existing and proposed bio-engineered or bank hardening projects on salmon EFH, including prey species before planning new bank stabilization projects; and

- Develop plans that minimize alterations or disturbance of the bank and existing riparian vegetation.

Conservation Measures for Construction/Urbanization–Activities associated with urbanization (*e.g.*, building construction, utility installation, road and bridge building, and storm water discharge) can significantly alter the land surface, soil, vegetation, and hydrology and subsequently adversely impact salmon EFH through habitat loss or modification. In order to minimize these impacts, the USDA-ARS and the applicant should:

- Plan development sites to minimize clearing and grading;

- Use Best Management Practices in building as well as road construction and maintenance operations such as avoiding ground disturbing activities during the wet season, minimizing the time disturbed lands are left exposed, using erosion prevention and sediment control methods, minimizing vegetation disturbance, maintaining buffers of vegetation around wetlands, streams and drainage ways, and avoid building activities in areas of steep slopes with highly erodible soils. Use methods such as sediment ponds, sediment traps, or other facilities designed to slow water runoff and trap sediment and nutrients; and

- Where feasible, reduce impervious surfaces.

Wastewater/Pollutant Discharges–Water quality essential to salmon and their habitat can be altered when pollutants are introduced through surface runoff, through direct discharges of pollutants into the water, when deposited pollutants are resuspended (*e.g.*, from dredging or ship traffic), and when flow is altered. Indirect sources of water pollution in salmon habitat includes run-off from streets, yards, and construction sites. In order to minimize these impacts, the USDA-ARS and the applicant should:

- Monitor water quality discharge following National Pollution Discharge Elimination System requirements from all discharge points;

- For those waters that are listed under Clean Water Act section 303 (d) criteria (*e.g.*, the Delta), work with State and Federal agencies to establish total maximum daily loads and develop appropriate management plans to attain management goals; and

- Establish and update, as necessary, pollution prevention plans, spill control practices, and spill control equipment for the handling and transport of toxic substances in salmon EFH (*e.g.*, oil and fuel, organic solvents, raw cement residue, sanitary wastes, *etc*.). Consider bonds or other damage compensation mechanisms to cover clean-up, restoration, and mitigation costs.

VI. STATUTORY REQUIREMENTS

Section 305 (b) 4(B) of the MSA requires that the Federal lead agency provide NMFS with a detailed written response within 30 days, and 10 days in advance of any action, to the EFH conservation recommendations, including a description of measures adopted by the lead agency for avoiding, minimizing, or mitigating the impact of the project on EFH (50 CFR §600.920[j]). In the case of a response that is inconsistent with our recommendations, the Corps must explain its reasons for not following the recommendations, including the scientific justification for any disagreement with NMFS over the anticipated effects of the proposed action and the measures needed to avoid, minimize, or mitigate such effects.

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